A REPORT

ON THE

Geology of the Middle and Upper Silurian Rocks

OF CLARK, JEFFERSON, RIPLEY, JENNINGS AND SOUTHERN DECATUR COUNTIES, IND.

BY AUGUST F. FOERSTE.

GENERAL INTRODUCTION.

The rocks of Indiana occur in layers or beds which may often be traced for many miles. While they vary considerably in thickness at distant points, they often preserve nearly the same thickness for several miles, and if followed only a few hundred feet, show no appreciable difference as regards thickness. Along deep valleys the same layer or sheet of rock may be traced along one side of the valley to a point where it forms part of the bed rock of some stream, and then it may be followed along the other side of the valley back again to a point opposite that from which the investigator started. After several observations of this nature it will not be difficult to arrive at the conclusion that the same layer once extended entirely across the valley; in other words, that there was a time when the valley did not exist and when the layer of rock was continuous. The valley was formed at a later time by the erosive action of some creek or stream. How streams manage to wash out valleys in rocky countries, leaving originally continuous sheets more or less separated, has often been carefully investigated, and subjects of this kind had better be studied after reading some one of the more popular books on geology. It will then be discovered that, originally, continuous

layers of rock, not only once extended across the gap now formed by valleys, but also reached the now isolated and distant hills. In other words, the same layer of rock once extended for many miles in a continuous sheet over parts of the country now broken up by valleys and hills. At that time there were no valleys and hills, such as we now see in these districts. The valleys were formed later, and when, in the course of time, the rock in certain places was weathered away, and the broken up material was washed away by streams and rains, wherever a part of the rock remained standing, a hill was left behind, and wherever the depression between the hills was deep enough, a valley was formed. Hills and valleys are therefore cut out from once level stretches of land.

While the same layer of rock often preserves the same color, grain and chemical character for many miles, it is very common to find a certain amount of variation between the different layers exposed at any one locality. Sometimes the layers overlying each other may present essentially the same characteristics. For instance, in the quarries at New Point, Osgood and Harris City, from ten to twenty layers of rock are all of a white color, have a very fine grain and very nearly the same chemical composition. The layers differ only in thickness. A group of layers of this kind may be classed together and given a separate name. In the case just cited, the name Laurel limestone is used for these beds. About 10 or 15 feet below the base of these white limestones is found a salmon-brown limestone bed varying usually from $1\frac{1}{2}$ to $3\frac{1}{2}$ feet in thickness. It is coarser grained, and, as the color would indicate, has a somewhat different chemical character. This rock is called the Clinton. The space between the Laurel bed and the Clinton is composed of a number of layers of material which differ considerably from each other. Some of the layers consist of limestone, most of them of clay, a part of the clay often forming a fairly hard rock. Each of the different layers could be given a separate name, but it is more practical to class the various layers, between the Laurel and Clinton layers, together and apply to them the single name, Osgood beds. Beneath the Clinton layer at Madison is the banded, brown and blue rock which forms the steep walls at the side of the Michigan and Telegraph roads, and at many of the waterfalls for miles around. Here, the layers for a vertical distance of 40 to 55 feet present essentially the same color, grain and chemical composition. These layers are grouped under the name Madison beds. Farther down there is a great mass of rock, consisting of thin layers of limestone and thin layers of clay or shale, alternating in a very irregular fashion and yet preserving essentially the same general features. Rocks of this nature extend down for nearly 300 feet, as far as low water mark on the Ohio River. One name could be given to this entire series, notwithstanding its great thickness. In this report they are called the fossiliferous

limestones below the Madison beds. As a matter of fact geologists use a name for these rocks which includes also the beds which we have just called the Madison beds. This name, used for both, is the Cincinnati Group. In the same manner the Osgood beds, the Laurel limestone and a considerable thickness of rock overlying the latter (the Waldron shale and Louisville limestone) have been classed together and form the larger associated series of rocks called the Niagara Group.

The various groups, large or small, present differences which can be readily recognized by persons who make rocks a study. Persons who have but moderate experience in the study of rock usually succeed in recognizing very readily the more characteristic groups in their own section of the country. In fact, groups can be recognized more readily than particular layers.

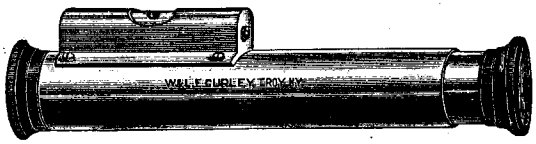
The same group presents essentially the same appearance for many miles, but the different groups may of course vary considerably from each other. If a person learns to distinguish the different groups as they are exposed along some hillside, and remembers their order of succession, he is in a much better position to recognize the fact that the same rocks must once have extended across valleys, and from hill to hill, that they must once have formed vast continuous sheets, not as yet broken up by valleys and hills. For, isolated hills will present the same groups of rocks with the same thickness, with the same order of succession and at the same level as the more continuous stretches of land, one or two miles, sometimes many miles, away.

While the different groups of rock can usually be readily recognized by means of differences in color, grain and chemical composition, they can be still more readily distinguished by means of their fossils. If, for instance, the fossils found in the Cincinnati, Clinton and Niagara groups be compared, scarcely a fossil found in one group will also be found in the other. Moreover, when the Osgood and Waldron beds, both belonging to the same group, are compared, the general type of fossils in each bed is quite distinct and may be easily recognized, although a number of fossils are found at both levels.

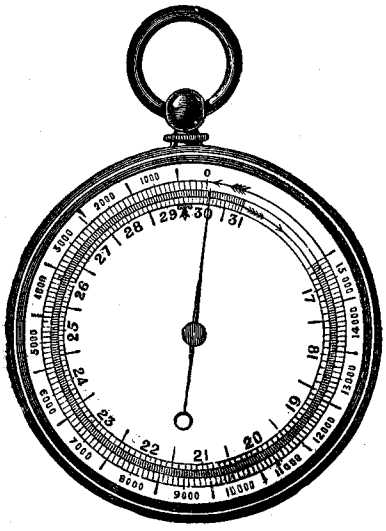
This being the case, if a person recognizes one bed or a series of beds of rock, and knows the order of succession of the different groups, he can tell what groups of rocks should be found above, and what groups should be found below the group first examined. It is not necessary to have all the groups exposed. If he remembers the thickness of the different groups he can in a measure predict at what level the other groups will be found in case the earth is removed. For this reason a collection of statistics regarding the various outcrops of rock at different localities becomes valuable not only in order to inform the investigator where certain layers of rock occur but also to enable him to locate other beds of rock by means of the data already discovered. If, for instance, it is desired to learn if

the Laurel limestone is present in any locality, it is necessary only to accurately locate the top or bottom of some group of rocks in the immediate vicinity of the area to be investigated. Then, knowing how many feet up or down from this recognized horizon the desired group of rocks should occur, it is necessary only to find a hill high enough or a valley deep enough to expose the same. If the ground is very sloping and is traversed by brooks, go down stream for lower layers of rock and up stream for higher ones.

For work of this kind a pocket level, such as that manufactured by W. & L. E. Gurley of Troy, New York, is very serviceable.



Placing this to the eye, whatever is seen at the same level as the moving bubble of air, is at the same level as the eye, and, therefore, a definite distance above the level of the ground upon which the observer is standing. If a person wishes to ascend 35 feet above a certain point and his eye is five and one-half feet above his shoe sole, he should place himself on the layer of rock which he uses as a mark from which to measure. Whatever object is on the level of his eye is five and one-half feet above this layer. Then let him walk to that object, and, standing in this new position find some other point on the same level as his eye. After he has repeated this operation six times, he is 33 feet above the layer of rock from which he began to measure. Two feet above the object last sighted is 35 feet up. By this means it is possible to locate quickly and quite accurately any level above or below any starting point, along a hill slope where the rise or fall of the level is too gradual to admit of less accurate means of determining vertical distance.



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When it is desirable to compare levels at distant points, an aneroid barometer not registering more than 3,000 feet is very serviceable. The pointer will indicate some number of feet at the locality where the observer first stands. It will indicate another number at the locality whose relative level he desires to know. If one number be subtracted from the other, the relative difference in level is obtained in feet.

This instrument is sometimes especially made for purposes of surveying, the dial or face of the instrument being made larger. It is, of course, not as accurate as a good level, and is rather expensive. If, however, it be desired to investigate any large area of country, it will be found sufficiently accurate for several miles for most purposes, provided the investigator learn the proper use of the instrument. Books explaining the use of the instrument can be secured from the manufacturers.

Both of these instruments have been used to a considerable extent, in the preparation of this report, in measuring the thickness of the rocks, and in tracing the same layers from exposure to exposure.

THE SUBJECT OF THE REPORT DEFINED.

The following report is an investigation of the Middle Silurian rocks of southern Indiana. It includes, incidentally, also, notes upon the upper layers of Silurian rock. The Silurian rocks of Indiana are divided into two great divisions—the Lower and Upper Silurian. Only the upper portion of the Lower Silurian rocks are exposed in Indiana. The lowest division here investigated was the gasteropod layer, which, although 140 feet beneath the top of the Lower Silurian, is still many hundred feet above the bottom of this set of rocks, the base of the Lower Silurian being found far below the level of the oldest rocks in the State. Little attention is paid to the richly fossiliferous shales and limestones which extend from the gasteropod layer up to within 60–40 feet of the top of the Lower Silurian. Considerable more attention is given to the Madison beds, which are 40–55 feet thick, and which form the upper part of those Lower Silurian rocks which are exposed in Indiana. The Upper Silurian, receiving the most attention in the body of this report, includes the following strata, going upward: The Clinton, never more than five feet thick; the Osgood beds, 15–25 feet thick; the Laurel limestone, 35–45 feet thick; the Waldron shale, 5–10 feet thick, and the Louisville limestone, 40–55 feet thick.

The following section will express in brief form the relationship between the different rocks:

UPPER SILURIAN.	Niagara Group....	Louisville limestone or Utica lime rock.
		Waldron shale.
		Laurel limestone or Cliff Rock.
		Osgood or Cystidean beds, divided in places into the *a*. Upper Osgood clay. *b*. Osgood limestone. *c*. Lower Osgood clay.
	Clinton Group	Clinton limestone.

LOWER SILURIAN.	Cincinnati Group..	Madison beds and their northern equivalents. Overlying the typical Madison beds are the *Murchisonia hammelli* beds and the terminal white limestone layer.
		The richly fossiliferous shales and limestones below the Madison beds. The equivalents of the Madison beds northward present the same characteristics as these lower beds.
		The gasteropod or Marble Hill bed.
		A great section below not studied.

A number of the minor subdivisions are here named and defined for the first time. The names are taken from localities near which typical exposures may be found.

The Louisville limestone is named after the fine exposures of this limestone east of Louisville, which have furnished most of the fossils cited from the Louisville Niagara. The fossils have been redescribed and figured recently by Nettleroth in the publications of the Kentucky survey. The Waldron shale is named after the exposure at Waldron, in Shelby County, Indiana. The fossils of this group were described and figured by Hall in the publications of the Indiana survey. The Laurel limestone is named after Laurel, in Franklin County, Indiana, in the vicinity of which town there are many small quarries. The Osgood beds are named after Osgood, in the vicinity of which town the upper part of this formation has furnished many fossils. The fossils of this group still await study. The large number of species of cystideans described by S. A. Miller in the various publications of Indiana, Illinois and elsewhere, are derived from this formation in southeastern Indiana. The divisions of the Osgood beds into upper and lower clays and the intermediate limestone bed, are typically exposed at localities 58 and 75, in northern Jefferson County. The Clinton limestone is the continuation of a limestone bed found in Ohio and identified as the Clinton by Prof. E. Orton and others. The name has been retained for the western extension of this formation. The fossils of this formation have been described and figured by Foerste in the Ohio reports.

The Madison beds receive their name from Madison, in Jefferson County, Indiana. Although the name Madison has already been once used to designate the Lower Silurian rocks exposed at Madison, it has never been adopted, and the prior name, Cincinnati group, is the only one ever used for these rocks even in Indiana, therefore the name is practically free to designate a much more special group of rocks at the very top of the Lower Silurian typically developed at Madison and in the more immediate vicinity. The typical Madison beds are scantily fossiliferous and

contain only the ordinary Cincinnati group fauna. A few of the fossils of the *Murchisonia hammelli* beds, above the typical Madison, have been described by S. A. Miller in publications of the Indiana survey and elsewhere. The general Cincinnati group fauna has been described in the publications of many surveys in addition to those of Ohio and Kentucky.

Very few persons probably have a conception of the monetary value of a good collection of fossils. The collection made by Prof. Hall, of New York, in the vicinity of Waldron, was worth several tens of thousands of dollars. The specimens of Holocystites and other cystideans found in the Osgood bed bring a good price if well preserved. Even the very common Cincinnati group fossils, if well preserved, find a ready sale. It is rather surprising that persons of large means have not undertaken the *systematic* exploration of fossil beds for the purpose of supplying college cabinets and museums with comparatively full sets of fossils of different formations at fairly reasonable prices. Indiana possesses several horizons which could be well exploited.

In the following pages are described, first, the various principal groups or beds of rocks, as indicated in the preceding section, and next, the various localities visited which present features of interest. The careful description of these localities certainly ought to serve as a good basis from which to determine the location of other desirable rock. At the close of the report will be found a few suggestions regarding the more valuable formations found in the area investigated.

DESCRIPTION OF THE VARIOUS FORMATIONS STUDIED.

THE GASTEROPOD LAYER.

At Marble Hill, near the southern border of Jefferson County, there is a stratum of Lower Silurian rock, about 140 feet below the Clinton, or 80 feet below the Madison bed, which is full of gasteropod remains. The stone is of a white color, and the presence of the gasteropod shells promised to give the stone superior commercial value. It was found, however, that the stone would readily disintegrate under the influences of weathering, and the quarry has therefore been abandoned. This gasteropod layer occurs also five miles southwestward, at locality fifteen, 133 feet below the Clinton; three and a half miles northwest (22),* about 120 feet below the Clinton; four miles northward (25), 147 feet below the Clinton; and four and a half miles northward (26), 133 feet below the Clinton. The most distant points are nine miles apart.

*The numbers refer to the localities on the maps which accompany this report.

FOSSILIFEROUS LIMESTONES BENEATH THE MADISON BEDS.

Below the gasteropod layer, and also above the latter, the lower Silurian consists chiefly of interbedded layers of limestone and clay, both being often abundantly fossiliferous. In some regions these richly fossiliferous limestone and clay beds terminate quite abruptly 40 to 60 feet beneath the Clinton, and are overlaid by a very argillaceous rock, or very impure limestone, which is described in the next section under the name of the Madison bed.

The top of the richly fossiliferous, thin limestones is found possibly 40 feet below the Clinton at locality 6; 34 feet below at 7; 46 feet at 12; 40 feet at 14; 38 feet at 15; 61 feet at 18; over 54 feet at 22; 32 feet at 23; 67 feet at 25; 47 feet at 26; 49 feet at 33; about 60 feet at 34; 40 feet at 37; 63 feet at 40; at 50 feet at 41; 34 feet or more at 42; 58 feet at 46, and 38 feet at 57.

Where the Madison beds are not present, thin fossiliferous limestones and clays are found at much higher altitudes, even as far up as the base of the Clinton. The measurements above given have significance, therefore, only in regions where the Madison phase, at the top of the Lower Silurian, occurs.

THE MADISON BEDS.

In the vicinity of Madison, the top of the Lower Silurian is formed by a considerable thickness of argillaceous limestones, weathering on long exposure from light brown, more or less banded with darker brown, to even purplish tinted layers. Although not entirely unfossiliferous, the fossils in these argillaceous limestones are confined to a few layers, and by far the greater part of the layers are without fossil remains. Beneath the banded limestones occur eight feet of the *Favistella* bed, which near Madison seems to form a well marked horizon. The banded limestones are inclined to form vertical walls, owing to their massive character, and owing to the wearing away of the softer shales and clays at their base. This is especially true along the beds of streams, so that the banded limestones often form steep walls, over which plunge the many picturesque falls of Jefferson and Clark Counties. The banded limestones have a thickness of 30 to 32 feet in the vicinity of Madison, and together with the underlying softer shales and the included *Favistella* beds of the latter, constitute a well marked horizon in Jefferson and Clark Counties.

The most southern exposure of the Madison bed, showing all the characters typical of this rock, is along Lick Run, southeast of Charlestown (6), where it seems to be 40 feet thick. It unquestionably has a still greater southern and western extension. At locality 7 the characteristic Madison bed is only 16 feet thick, but is underlaid by 13 feet of beds,

some of the layers containing a few fossils, and by five feet of clay, which corresponds to the base of this horizon elsewhere. At 12 it is 46 feet thick; at 14, 47 feet; at 15, 34 feet; at 18, 48 feet; at 22, 54 feet; at 23, 30 feet; at 25, 65 feet; at 26, 45 feet; at 29, the upper 20 feet of the Madison bed are harder, and project over the softer Madison beds beneath; at 33 they are 37 feet thick; at 34, 60 feet; at 37, the typical Madison bed, 30 feet thick, is underlaid by about eight feet of shaly material, forming the base of this horizon; at 38 a similar exposure occurs; at 40 the typical Madison bed, 35 feet thick, is underlaid by a considerable thickness of shales, certainly more than 12 feet; at 41 the typical Madison, 30 feet thick, is underlaid by at least 17 feet of shaly material; at 42 the typical Madison, 34 feet thick, is underlaid by the more shaly beds, which here contain fucoidal markings; at 46 the typical Madison, 40 feet thick, is underlaid by 18 feet of clayey shale with fucoidal markings.

At 55, the upper part of the Madison bed changes to a soft, whitish limestone; at 57, the upper part of the Madison changes also to a considerable extent into a soft, whitish limestone, 20 feet of this phase being underlaid by 15 feet of typical Madison stone. At 60, the Madison bed is underlaid by shaly courses containing *Favistella* below. The shale phase at the base of the Madison bed occurs, according to the preceding notes, chiefly in the vicinity of Madison and northeastward. The Madison occurs at all points southwest of Madison in Jefferson and Clark Counties. North of Madison it occurs in typical form as far as 36, 40, 41, and points northeastward; east of Madison all the exposures show the Madison bed.

The Madison bed seems to have approximately the same distribution as the fine-grained, light brown or reddish brown, more sandy Clinton to be described later, but it extends farther westward than that phase of the Clinton at almost all points, except in the northern part of Jefferson County. This similar distribution of the Madison bed, and of the sandy phase of the Clinton, unquestionably is due to a similar physical history.

The Madison bed not infrequently includes thin layers of limestone enclosing a few fossils of Lower Silurian age, chiefly *Orthis occidentalis* and various bryozoans. These layers are never frequent at any one locality, and are often entirely absent. They are especially likely to occur near the base of the typical Madison beds, and at their very summit. In the shaly courses below the typical Madison beds *Favistella stellata* is a not uncommon fossil. It usually occupies one or two layers about 8 to 15 feet below the typical Madison bed. It occurs at 33, 37, 38, 40, 41 and 60.

The typical Madison bed is commonly overlaid by other rock, the Clinton being found several feet higher up. This intervening rock is

commonly a bluish, fine-grained limestone, with fossils, and of no commercial value. Sometimes it is an ordinary blue limestone, containing fossils chiefly along the partings between the different layers. *Murchisonia hammelli*, *Holopea hubbardi*, a small species of *Orthoceras*, *Leperditia cœcigena* and other fossils are especially characteristic of this horizon. One or more of these species are found at localities 14, 23, 25, 26, 28, 37, 38, 39, 40, 42, 55, 56, 57, 70 and 84. These beds might be called the *Murchisonia hammelli* beds. They vary from a few inches to five feet in thickness. Large masses of Labechia are not uncommon fossils in the clay layers which occur at various levels in these upper limestones; they are found at localities 15, 23, 25, 26, 29, 30, 31, 37, 40, 42, 55 and 56. *Tetradium minor* is found at the top of the Lower Silurian at 14. Both *Labechia* and *Tetradium* continue to be exposed at or near the top of the Lower Silurian in the exposures farther northward beyond the region occupied by the typical Madison phase of the Lower Silurian or the overlying *Murchisonia hammelli* bed.

The very top of the Lower Silurian, in the neighborhood of Charlestown, at localities 1 and 7, is formed of a fine-grained white, hard limestone four to six inches thick. At 13 and 18 the top of the Lower Silurian is a sandy limestone, 80 to 84 inches thick, and difficult to distinguish from the overlying Clinton. From the vicinity of Hanover (28) to Clifty Falls (36) and northeastward (49, 56, 57) the top of the Lower Silurian is often formed by a bluish limestone layer four to 10 inches thick and often containing *Leperditia cœcigena*. This layer is much better developed in Ripley and Jennings Counties, where it furnishes the material for the pebbles in the Clinton. It there, however, rarely contains *Leperditia*

NORTHERN EQUIVALENTS OF THE MADISON BED.

North and northwest from the typical Madison bed, the top of the Lower Silurian rapidly changes its character. It is replaced by a series of blue, often rather dark blue, very fine grained limestone. This limestone where quarried often seems to be very solid, but it will not withstand weather. Where long exposed in the banks of streams it is traversed in many directions by close, minute cracks, along which the rock is often discolored to an iron-stained brown or even a purplish color. The rock often contains *Leperditia cœcigena*, *Isochilina subnodosa*. Lithologically, this rock is similar to the dark blue, fine grained layer forming part of the *Murchisonia hammelli* layer in more southern areas. The first change of the Madison beds northwards consists in fact in the alteration of the Madison beds, so as to present the same lithological characteristics as the blue beds which southward, near Madison, only overlie the Madison beds. The fine-grained dark blue limestone, taking the place of the

Madison beds, is interbedded with ordinary limestones, and with clays containing ordinary limestone fossils. Sections of this type begin to be exposed in northern Jefferson County, and are typically developed at Versailles, along the whole length of Big Graham Creek, and for some distance northwards. The correspondence of this section is very well seen in the exposure immediately north of Versailles, where 29 feet of this limestone, with its intercalated beds of clay and shale, are underlaid by 11 feet of unfossiliferous brownish and bluish shales, corresponding to the shales at the base of the Madison beds near Madison. Below the shales are 12 feet of limestone and shale, containing *Tetradium minor* at many levels, and *Favistella stellata* at the very base. This is the characteristic horizon for *Favistella* in southern Indiana. The shale bed of the preceding section is exposed also at locality 109.

From the Baltimore & Ohio Southwestern Railroad northwards, all comparison with the Madison beds is lost. The upper strata consist commonly of thin or shaly limestones, interbedded with clays, both usually abundantly fossiliferous. No demarcation can be made between these upper strata and the lower horizons of the Lower Silurian, corresponding to the separation of the Madison from the richly fossiliferous shales in southern Jefferson and in Clark Counties. This means that the Madison beds are replaced northwestward by limestones, just as the sandy Clinton is replaced northwestward by pure limestones.

TERMINAL LOWER SILURIAN WHITE LIMESTONE.

At many points in Ripley, Jennings and Decatur Counties, the upper part of the Lower Silurian is terminated by a white, fine-grained limestone, which immediately underlies the Clinton and which has furnished the material for the pebbles inclosed in the latter. In many places it closely resembles lithologically some phases of the Laurel bed, although it is usually a softer stone. It occurs at localities 102, 107, 110, 111, 114, 116, at New Point, 123, 125, 126, 130, 133, 134, 135, 138, 142, 146, 148, 161, 162, 163, 164, 165, 170, 178, 179, 181, 182, 183 and 193. This limestone varies usually from 4 to 8 inches in thickness, but occasionally reaches from 12 to 15, and in one case 48 inches in thickness. In the northwestern part of Ripley County, the northeastern part of Jennings County, and the adjacent parts of Decatur County this white limestone often contains fossils, especially *Strophomena alternata*.

At several localities this layer of white limestone is penetrated by worm burrows, which have been filled in again with detrital material, whose salmon-yellow color suggests that these burrows were made by animals during Clinton times. Such burrows exist at 110 and 146, for instance. At 135 the top of the white limestone shows cracks of the type usually called sun cracks. The salmon-brown Clinton resting upon this limestone has filled in all of the cracks.

OÖLITIC CONCRETIONS.

The thicker layers of limestone in the upper part of the Lower Silurian from Osgood to Nebraska, and northward as far as the Decatur County line, frequently contains oölitic concretions of large size, often a quarter of an inch in diameter. The concretions frequently enclose fragments of Lower Silurian fossils, especially fragments of brachiopods and pieces of branching bryozoans. Their geographical distribution is about the same as that of the pebbles which occur in the Clinton.

CLINTON.

The greatest recorded thickness for the Clinton in Clark County is 32 inches or two and two-thirds feet. At no point is it known with certainty to be entirely absent. Where this appears to be the case, near Charlestown Landing, the apparent absence is due to a peculiar horizontal sliding and faulting in the rock, to be described elsewhere. The salmon-brown color, so typical of more northern exposures, is shown only by the most southwestern exposures (1, 5, 7). Even at these localities a large part of the Clinton limestone is of a light red color, only a portion of the rock being of a salmon-brown color. At all the remaining exposures in Clark County the Clinton is of a whitish, light brown, or a light, reddish brown color; the rock is usually fine grained and hard, occasionally becoming coarser grained, and containing crinoidal remains. Recognizable fossils are very rare.

The light brown or reddish brown Clinton rock continues northward into Jefferson County, along the regions nearer the Ohio, to a point about five miles north of the county line. However, the more western exposures in the southwestern corner of Jefferson County, at Dog Falls and westward, and those from Hearts Falls, through Hanover to the horse-trough on the Madison–Hanover pike, have the typical salmon-brown color. The salmon-brown Clinton continues to be exposed from the northern branches of Crooked Creek, and from the southern end of Hall's Ridge northward beyond the county line. Along the Ohio River near Madison, however, in the area northeast of Madison, and in the northeastern corner of the county, the Clinton is usually a fine grained, light red or reddish brown rock, with few fossils. The salmon-brown Clinton usually contains abundant fossils, although these are usually imbedded in the solid rock.

In Jefferson County the Clinton rarely exceeds 36 inches in thickness, although thicknesses of 45 and 52 inches ($3\frac{3}{4}$—$4\frac{1}{3}$ feet) are reached. At no point is it known to be entirely absent.

The siliceous, light red or reddish brown, fine grained form of the Clinton continues from the northeastern corner of Jefferson County northward into Ripley County, toward Olean. The salmon-brown, coarser-grained Clinton occurs farther westward.

Sufficient data are not at hand to enable any one to discuss with confidence the areal distribution of the two lithological types of Clinton in southern Indiana. At present, however, it seems as though the fine-grained, light brown or reddish brown Clinton occupied a great area east of the salmon-brown crinoidal Clinton.

A line connecting localities 1, 5, 7, 23, 24, 27, 28, 29, 30, 31, 33, 34, 40, 41, 52, 53, 62, 63, 68, 82, 89, 90 and 94 will indicate in a general way the eastern outcrops of the salmon-brown Clinton. West of this line the Clinton is of a salmon-brown color and is coarser-grained. East of this line the Clinton has a more light reddish brown color, is fine-grained, and possesses more sandy material and less lime. The salmon-brown Clinton near the eastern border of its area of distribution frequently contains lenses of a white, fine-grained rock. This rock occasionally forms continuous sheets for several feet, but usually occurs only in small patches, evidently once continuous. The forces which removed the intermediate parts have occasionally broken up these sheets more roughly and left the fragments in a more angular form in the salmon-brown Clinton. These, then, must not be confounded with the pebbles of Lower Silurian origin which are often found inclosed in the Clinton in various parts of Ripley County. The pebbles of Lower Silurian origin are usually derived from a still more fine-grained, very dense, white limestone, which is the terminal Lower Silurian white limestone or a layer at the top of the Lower Silurian, parts of which are often still preserved *in situ* in southern Indiana. Pebbles derived from this limestone are found at several localities two and three miles west of Cross Plains (88, 89, 90).

With the exception of the small area in the southeastern part of Ripley County, south of Olean, the Clinton formation of Ripley, Jennings and Decatur Counties has the salmon-brown color typical of the Clinton in southern Indiana. The greatest thickness of Clinton limestone recorded in Ripley County is 64 inches or $5\frac{1}{3}$ feet, in Jennings County is 11 inches, and in southern Decatur County, south of the Big Four Railroad, is 28 inches. From these measurements the thickness of the Clinton decreases to nothing, so that the Clinton is absent at some points in all three of these counties.

In this case it is again difficult to define with certainty the area over which the Clinton is absent. The most eastern and northern outcrops where it is absent are 130, 131, 152, 153, 159, 180, 164, 178, 190 and 191. East and north of this line the Clinton has been found present in all the sections actually examined, although it is often only 15

inches or less in thickness. West of this line the Clinton is almost everywhere absent. Local patches of Clinton, however, are found in places within the area where it is usually absent. Clinton 11 inches thick is found, for instance, in Jennings County, at locality 182; Clinton 4–10 inches thick, including pebbles of dense white Lower Silurian limestone, occurs at 174; Clinton 2–3 inches thick, including pebbles, is found also at 167. The geographical extent of these Clinton patches in the general Clinton-less area seems to be small. The southern border of the area within which the Clinton is absent is still more difficult to define. The border seems to be very irregular, and to cross the Big Graham several times. The Clinton is absent at localities 130, 131, 132, 138, 140, 136 and 166. It is only one inch thick, and contains Lower Silurian pebbles at 137 and 165. It is present, however, and varies from 6 to 22 inches at 133, 139, 135 and 134. This last patch of Clinton is probably connected with the main body of Clinton southward and eastward. The western extent of the area in which the Clinton is absent is, of course, unknown.

The Clinton-less area was unquestionably either above water or covered only by very shallow depths of the sea during a part or the whole of the Clinton period. Around its margin, as might be expected, pebbles composed of the upper layers of Lower Silurian rock are very common. Such Such pebbles are found, for instance, at 165, 137, 135, 134, 133, 139, 129, 127, 128, 126, 125, 124, 123, 100, 143, 142, 102, 105, 106, 107, 149 and 162. The frequency of these pebbles in the region east of the area where the Clinton is altogether absent suggests that even these regions may at times have been above water, or have been at least covered only by shallow waters during the earlier part of the Clinton period.

The following condensation of the previous observations may be of value: The Clinton of southern Indiana is usually a salmon-brown, rather coarse-grained limestone. In the southeastern parts of Clark, Jefferson and Ripley Counties, however, roughly between Charlestown Landing and Olean and southeastward, the Clinton is replaced by a more sandy, finer grained, light brown, or reddish brown, limestone. In those parts of Ripley, Decatur and Jennings Counties lying west of a line connecting New Marion and Millhousen the Clinton is usually absent, and was once above the sea, or at least under very shallow water.

BASAL NIAGARA LIMESTONE.

The *basal Niagara limestone* has been recorded as existing in Clark County at only one locality, 8, opposite the mouth of Collins Run. It was not especially looked for, and may have escaped attention. In the southwestern portion of Jefferson County it is a white limestone, often

rather soft, varying from 8 to 15 inches, sometimes to 22 and even 32 inches in thickness. In the vicinity of Madison, at Hanging Rock, along the Madison pike, on the pike to Manville, and in Lonesome Hollow the salmon-brown Clinton is overlaid by a light brown, siliceous limestone, on which rests a gray limestone. The latter has been called the basal Niagara limestone, and the former has been considered a transition rock between the Clinton and the Niagara. The total thickness of these layers usually varies between 16 and 24 inches. Between the localities in the vicinity of Madison, just mentioned, and the northern boundary of Jefferson County, the basal Niagara limestone usually varies between six and eight inches.

In Ripley County, near the head branches of the east fork of Indiankentuck Creek, it is a siliceous, reddish-brown limestone about 10 inches thick. Near New Marion and westward the basal limestone varies from 8 to 11 inches. Near the county line on the Big Graham it is reduced to three inches. On the Big Otter Creek, near the county line, it is 12 to 15 inches thick. In the northwestern angle of Napoleon and north of Napoleon it is reduced to two to four inches in thickness. In Jennings County there is an increase to 16 inches at the most westerly exposure on the Big Graham, while the most western exposure on Otter Creek, shows a thickness of only two to three inches. Variable thicknesses are also shown northwards. In Decatur County, on upper Sand Creek and Cobb's Fork, it measures two to four inches. East of Westport it is about 15 inches thick.

While the basal Niagara limestone is not found in all localities, it has a very wide distribution, a comparatively uniform thickness, presents very constant lithological characteristics, and is almost always present when the Clinton is absent. It is rarely fossiliferous, but occasionally becomes crinoidal and may even contain well-preserved fossils.

At one locality in Ripley County, on Big Otter Creek (152), a Clinton pebble was found inclosed in the basal Niagara limestone. The limestone at this place was very fine grained. It is the only instance of a pebble occurring in the basal Niagara so far noted. Nothing of the kind has been seen in corresponding rocks in Ohio.

LOWER OSGOOD CLAY.

Above the basal Niagara limestone, or, when that is absent, directly on the Clinton limestone, is found a bed of clay or of clayey shale, varying locally to an argillaceous limestone, or even to thin layers of rubbly limestone. It is here called the *Lower Osgood Clay Bed.* In Clark County it is usually a blue, clayey shale, about 11 feet thick. In Jefferson County it is a blue or light brown clay or clayey shale; sometimes it varies to a hard, indurated clay rock, and rarely into an impure

limestone. Southwest of Madison it varies from 8 to 10 feet in thickness; east and northeast of Madison it often reaches 14 and 15 feet in thickness. In the southern part of Ripley County it varies between 11 and 16 feet. Along Big Graham it is 6 to 8 feet thick. East of New Marion it is a clayey shale; west of New Marion it is a clay bed.

From Osgood, along the most southern tributaries of Big Otter Creek to the western part of the county, and thence northward to the northern end of the county, the Lower Osgood clay is no longer a uniform clay bed. It changes its character, the lower half remaining a soft clay or a clayey shale, while the upper half turns into a rubbly limestone. The transition is not a sudden one. The upper half of the Lower Osgood clay becomes a somewhat harder, indurated clay rock, along Big Creek, in Jefferson County. Farther north it occasionally shows similar features. Farther north, along Otter Creek, it becomes a clay rock containing irregular masses of limestone, and still farther north it is often a rubbly limestone; *i. e.*, a limestone with very irregular surfaces easily breaking up into irregular fragments, occurring in thin layers, usually varying between two and three inches in thickness.

This change of the upper half of the Lower Osgood clay bed into a rubbly limestone is accompanied by an alteration of the lower half into a harder indurated clay rock, which often looks so much like the Madison beds at the top of the Lower Silurian, that they would be taken for the latter were it not for their occurrence *above* the Clinton limestone. When it assumes this appearance it is often called the Madison-like clay bed in the body of this report. Along the upper tributaries of Big Otter Creek, the indurated lower clay, overlaid by the rubble limestone, have a total thickness of seven feet. Near the county line and on Brush Creek they are 9 to 12 feet thick. On the head waters of the Muscatatuck they are seven to nine feet thick. North of Napoleon they are reduced to 3 and $3\frac{1}{4}$ feet, but at New Point they are again seven feet thick. In Jennings County, along Otter Creek, they vary from 9 to 11 feet. Along the Muscatatuck and its various branches they usually measure from 7 to 10 feet in thickness. In some of the more northern exposures the upper half of the Lower Osgood clay does not present its usual rubble limestone characteristics. Instead of this, the limestone is occasionally an even bedded, fine grained but soft limestone. It takes this form also in Decatur County, along Squaw Creek, also on Sand Creek and its various tributaries.

Very often the rubbly limestone is decidedly crinoidal, and it occasionally shows very well preserved fossils.

THE OSGOOD LIMESTONE.

Above the Lower Osgood clay bed or its equivalents (the indurated clay bed, overlaid by the thin rubble limestones), there is almost everywhere a layer or a number of layers of limestone, very crinoidal in character, and usually presenting fossils on its upper surface and in the intercalated, thin clay beds.

This limestone occurs in the various exposures southeast of Charlestown, in Clark County. Along the head waters of Bull Creek and Camp Creek five feet of limestone belong to this horizon. The same thickness is shown at Marble Hill, in Jefferson County. At Clifty Falls, and from Madison eastward and northward, the limestone varies usually from three to four feet in thickness. Along Big Creek and in the southern part of Ripley County, a clay layer is usually found near the middle of several limestone beds occupying the Osgood limestone horizon. Along the Big Graham it is three feet thick. Along Big Otter Creek and its tributaries it is only one to one and one-fourth feet thick. It is also thin in the northern part of the oounty. Near Osgood, however, it is about 30 inches thick and is quarried for lime. The plaster made of this lime is said, however, to get very brittle after it has become old.

UPPER OSGOOD CLAY.

Overlying the Osgood limestone, in most of the localities investigated, is a thin clay bed. The most southern exposures recorded are on the head waters of Bull Creek, where it is represented by the shale varying from two to five feet in thickness. Near Kelly's mill, on Camp Creek (16), it is a blackish, clayey shale, three feet thick, containing a few limestone lenses and some crinoidal remains. In Jefferson County this upper Osgood clay is typically exposed in the vicinity of Madison, and thence northward, varying from three to five feet in thickness. In southern Ripley County and along the Big Graham it varies from four to five feet in thickness. Further northward the clay rarely exceeds one foot in thickness. It is often reduced to a few inches, and since the underlying Osgood limestone in the same area is also greatly reduced in thickness, these upper Osgood beds are difficult to distinguish from the lower Laurel limestone beds, when the latter also contains intercalated clay beds or are not typical lithologically. In Jennings County the upper Osgood clay is two to three and one-half feet thick on the Big Graham, and locally on Otter Creek and on Muscatatuck Creek near the mouth of Brush Creek. Elsewhere and also northward it is reduced in thickness, as is the case in Ripley County. When this is the case, the Osgood limestone and the base of the Laurel limestone are often very similar.

THE LAUREL LIMESTONE.

Overlying the more variable Osgood beds is a series of limestones presenting quite constant lithological features over considerable areas. It is well exposed in numerous quarries in the vicinity of Laurel, in Franklin County, whence the name. It usually is a very white, hard limestone, occurring in even layers, from four to 16 inches in thickness, which can be readily obtained in slabs of almost any desirable dimensions, forming a very valuable building rock. In Ohio it is known as the Dayton limestone. In Indiana it occurs, and is frequently quarried, in Wayne, Fayette, Franklin, Rush, Decatur, Ripley and Jennings Counties. The most southern localities where the typical rock is quarried to any extent are southwest of Versailles, at the Adam Caplinger (west of 123) and Tanglewood Church quarries; near New Marion (131, 132), in Ripley County; south of Nebraska (167), south of Butlerville (170), on Otter Creek, at San Jacinto, on the Big Graham, in Jennings County; and at the Reuben Walker bridge, two miles east of Dupont, in northwestern Jefferson County. Many good quarries could be opened along Big Creek east of the last locality. Good stone is exposed between Bryantsburg and Bellview, on tributaries of the west fork of Indiankentuck Creek (57), a mile and a half west of Canaan (59), and elsewhere.

South of Big Creek the Laurel limestone rapidly deteriorates in value, owing to the thinness of the courses into which it divides. Most of the courses do not exceed four to six inches in thickness on surface exposure, although it is possible that farther in the hillside some of the layers would be fairly well united. In the southern part of Jefferson County, along the Ohio River, the name *Cliff rock* is very appropriate, since the Laurel limestone usually forms the cliffs, projecting over the softer Osgood and Lower Silurian beds.

In southern Jefferson County the Laurel formation deteriorates not only in the thickness of the layers which can be quarried, but also in the quality of the stone. The rock is less pure, and becomes a softer, more argillaceous limestone. The result is that the Laurel limestone is not much quarried along the Ohio River as a building stone.

In northeastern Clark County, along Camp Creek (16), the limestone is fairly soft and argillaceous, and has a light brown color.

Its argillaceous character increases rapidly southwestward, until, in the neighborhood of Charlestown, along Fourteen-Mile Creek and its tributaries, it becomes a very argillaceous, decidedly brown limestone, which will not withstand the action of weathering. No one, without tracing the stone from place to place, would think of identifying the useless, brown,

argillaceous limestone of Fourteen-Mile Creek with the fine, hard, dense, white limestone east of Dupont, along Big Creek and more northern localities.

In the vicinity of Hanover, and for a few miles northward and southward, the top of the Laurel limestone is formed by five to seven feet of white, hard, solid limestone, which can not be quarried with the ease of the typical white Laurel limestone, but which, nevertheless, has been found very serviceable in this neighborhood, where all the other beds are of no value. The new science hall at Hanover College secured its stone from this white limestone ledge at the top of the Laurel limestone formation. The best exposures are found along the new Hanover Landing Road (31), above Butler Falls, at the road corner (29), and at localities 26, 27 and 34.

The Laurel limestone frequently contains chert layers. These are rarely found near the base of the formation in the area here investigated. An exception must be made in case of the exposures near Charlestown Landing and along Fourteen-Mile Creek, where the lower layers of the Laurel bed include chert layers. Since the Laurel beds here, however, have no commercial value, the occurrence of chert layers can cause no damage.

In the vicinity of Hanover, chert layers occur in the white limestone, at the top of the Laurel beds. The white limestone is here a valuable building stone, owing to the inferior character of the lower beds. The chert layers are, however, confined chiefly to the very top of the exposures.

Chert is also found near the top of the Laurel limestone near Canaan (59), at the Tunnel Mill south of Vernon, and elsewhere.

Farther north, where typical white, dense Laurel limestone is extensively quarried, very little chert is found until the quarries near Rossville, north of New Point, are reached. Here chert nodules damage some of the upper layers, and chert layers are found at the very top of the quarry. The chert is found within twelve feet of the base of the Laurel section, although not by any means within that distance of the rock actually quarried, the Osgood beds being also worked.

At Laurel the chert is found within five feet of the base of the Laurel formation.

At Longwood, Ball's quarry contains only the lower four feet of typical Laurel limestone, free from chert layers.

Indeed, from Laurel northward chert layers are commonly found within a few feet of the base of the typical Laurel limestone. It occurs even at New Paris, and at the quarries north of Fair Haven, in Ohio. Owing to the presence of chert only the lower layers of the Laurel formation are very valuable for quarry stone in these more northern regions.

WALDRON SHALE.

The white, fine grained limestone forming the Cliff rock or Laurel limestone is overlaid by a comparatively small thickness of clay or soft clayey shale. In the western part of Jefferson County south of Paris Crossing, in the northwestern part of the county southeast of Dupont, along Big Creek, and in the central part of Jennings County, at the Tunnel Mill, south of Vernon, this clay or clayey shale contains the typical Waldron fauna in sufficient abundance to be readily identified. Clay and clayey shale is found at the same horizon at numerous localities between Hanover, along the Ohio River, in Jefferson County, and Charlestown Landing, in Clark County. The more southern localities are, however, rarely fossiliferous, and even when fossiliferous rarely contain enough characteristic species to make the identification of the horizon of the clay possible upon purely paleontological evidence.

In the southern area here investigated the Waldron shale varies usually between 4 and 10 feet in thickness, although thicknesses of 14 and 20 feet are recorded locally. North of Vernon the fossiliferous Waldron shale is found at Hartsville, in the eastern part of Bartholomew County, and at St. Paul and Waldron, in the southeastern part of Shelby County. In the southern part of Rush County, at Moscow and at Milroy, the equivalent of the Waldron shale is said to contain comparatively few good fossils. In these more northern counties the shales vary from 1–6 feet in thickness.

The most southern locality with an abundant Waldron shale fauna, so far known, lies near Paris Crossing, about fifty miles south of the most northern one. Lithologically, however, the shaly clay can be traced nearly 30 miles farther southward to Charlestown Landing, and similar shaly clay has been recorded from the vicinity of Louisville, so that the Waldron shale may be said to occur in an area at least 90 miles long.

LOUISVILLE LIMESTONE.

The Waldron shale or clay bed is overlaid by an argillaceous or dolomitic limestone. Its usual color is light or medium brown, but where distant from the influences of weathering the brownish layers often show a bluish color. It is an argillaceous limestone. Locally or at certain horizons, however, the limestone is very white and closely resembles the cliff rock. The white limestone is much harder and will withstand the influences of weathering better than the brown layers. The white limestone forms the lower 20 feet of the Louisville limestone beds along the Ohio River front, from Begg's Run (4) to Utica, in Clark County. It is quarried as a building rock at a number of localities and is a very useful stone here, since the white, solid limestone belonging to the Laurel

GEOLOGICAL MAP OF EASTERN CLARK COUNTY, OUTLINING THE EASTERN BORDER OF THE UPPER SILURIAN.

By AUG. F. FOERSTE.

(Scale, 2 miles to the inch.)

formation is replaced along the Ohio River front, especially in Clark County, by a much inferior, softer argillaceous limestone. These white Louisville limestone beds are also worked at numerous points between Charlestown Landing and Utica for the manufacture of lime. It is sold extensively under the name Utica lime and is of excellent quality. White limestone is found in the lower half of the Louisville limestone section, also at the Tunnel Mill south of Vernon, in Jefferson County. It is not quarried there, however, since the Corniferous or North Vernon limestones are more satisfactory and are easy of access.

White limestone occurs also at other levels in the Louisville limestone section. Along the pike from Utica to Charlestown is found just below the Corniferous, and is quarried to some extent for building purposes. Except for the manufacture of lime, however, the beds of the Louisville limestone section have only local value.

The thickness of the Louisville limestone section seems to vary considerably. The average thickness is from 40 to 55 feet. Some sections exceed 60 feet, and, locally, sections as low as 25 feet and even 20 feet have been measured.

This may be due to the rapid variation in thickness of the upper Niagara beds, in tracing them from place to place, but it is not unreasonable to suppose that while a clay or clay shale, identified with the Waldron bed, is commonly present at about the same horizon in western Jefferson and in Clark County, this clay bed in different sections appears in reality at slightly different levels, thus giving rise to a considerable variation in the measurements of the thickness of the overlying Louisville limestone beds.

SPECIAL DESCRIPTION OF THE MORE IMPORTANT LOCALITIES.

CLARK COUNTY.

A. FOURTEEN MILE CREEK AND VICINITY.

The Corniferous is exposed along the Charlestown-Utica turnpike about a mile and a half north of Utica. Its base is 65 feet above the level of the river road at Utica.

Immediately below the Corniferous is exposed the upper portion of the Niagara, which is here a limestone containing frequent fossils. Among these are *Pentamerus nysius var. crassicostatus, Strombodes pentagonus, Favosites favosus, Halysites catenulatus, Cladopora and Lyellia.*

The *Corniferous* is exposed on the road leading northwestward from Charlestown Landing, a short distance from the Ohio River. Its base is about 200 feet above the level of the Ohio River.

*1. The *Charlestown lime rock* is quarried by Mr. Stillman on the east side of the road, near the top of the bluff above the Landing. The top of the rock quarried lies 50 feet below the base of the Corniferous. There are at least 17 feet of the lime rock exposed. The stone is whitish in color and contains small crinoidal remains and *Atrypa reticularis*. The general appearance of the rock is very similar to that of the Cliff rock or the Laurel bed in the more northern counties, but is dissimilar to the variety of the Cliff rock exposed at the Landing.

The *Waldron shale* is represented by five to six feet of clay, lying immediately beneath the quarried stone. Associated with this clay in the bed of a branch west of the road are a few thin limestone layers, showing *Caryocrinus* and other fossil remains.

The *Laurel beds*, beneath the clay, are 41 feet thick. They occur in quite regular layers, and where fresh are of a bluish color, though, owing to weathering, the usual color is brown. Along the roadside a few chert layers, five inches thick, occur in the lower part of the series. In the gully immediately west of the road there is a greater number of chert layers present.

The *Osgood clay* is about 18 feet thick. It is a clayey, thin shale, excepting near the base, where a somewhat firmer bed occurs. *Spirifer niagarensis* was the only fossil recognized. It was impossible to distinguish between the upper and the lower clay bed, the intermediate Osgood limestone not being in place.

The *Osgood limestone* was present, however, on the hillside in the form of several large blocks, one of which had a strike of N. 20 W., and dipped 70 W. The limestone had been brecciated and then recemented. It contained *Pisocrinus gemmiformis*. In the gully this limestone is violently folded and brecciated, but does not admit of good stratigraphic measurement.

The *Clinton limestone*, whose stratigraphic position is below the Lower Osgood clay, is present on the hillside, east of the road, in the form of blocks and slabs, lying at various distances from each other in the clayey shale. Their general dip is northeastward. The thickness varies from 20 to 26 inches. Some of the rock has the typical salmon-brown color, but a large part of it varies to a light reddish color, and is very hard. The following fossils were found: *Plectambonites transversalis*, var. *clegantula*, *Strophomena* (*Orthothetes*) *hanoverensis*, *Orthis calligramma*, var. *euorthis*, *Orthis* (*Platystrophia*) *biforata*, *Camarotœchia scobina*, *Phœnopora fimbriata*, *Pachydictya bifurcata*, *Pachydictya turgida*, *Heliolites subtubulatus*. In the gully the Clinton is not present.

Associated with the Clinton blocks are fragments of a very fine-grained white limestone dotted with little crystalline segregations two to three

*The numbers refer to numbered localities on the accompanying maps.

mm. in diameter. The fragments are usually four to six inches in thickness, and although at times overlying the Clinton, are known from other sections to belong immediately beneath the Clinton and to represent the top of the Lower Silurian.

The Lower Silurian, immediately beneath the series of Clinton blocks (omitting the fine-grained white limestone), is represented on the eastern side of the road by shaly clay, containing several Lower Silurian species of gasteropods and bryozoans. In the gully west of the road the Lower Silurian is exposed a short distance below the lowest brecciated Osgood limestone exposure. It there consists of layers of hard rock; one of the layers, about five feet below the brecciated Niagara, contains *Orthis (Hebertella) occidentalis*, and branching bryozoa.

It is evident that the portion of the section from the base of the Laurel bed to the top of the Lower Silurian has been considerably disturbed by geological agencies, so that the section can not be understood without a study of less disturbed regions.

2. Along a small stream entering the Ohio a short distance east of Charlestown Landing, within 50 feet of the river road, the *Osgood limestone* is much brecciated and folded. Several marked faults occur. *Pisocrinus gemmiformis* is found, as usual. The chief axis of folding and faulting seems to be N. 80 W., but the layer is contorted in various directions rather than folded.

3. The base of the *Corniferous* is exposed on the highland southwest of the mouth of Fourteen-Mile Creek.

Five feet below, along a short stream flowing into Fourteen-Mile Creek, the *Niagara* limestone contains *Halysites catenulatus*, *Cladopora* and *Strombodes pentagonus*. Dr. I. Work, of Charlestown, collected at this horizon several specimens of *Pentamerus oblongus*, var. *cylindricus*. Twenty-five feet below the Corniferous the Niagara contains corals, among these the *Strombodes pentagonus* again. Cherty concretions are not uncommon near this horizon.

The top of the *Waldron layer*, here represented by blue clay, is about 55 feet below the level of the Corniferous. The thickness of the clay is nine feet.

The *Laurel bed* or Cliff rock below is practically unfossiliferous. It is composed of layers of hard brownish or bluish rock, with chert layers at many levels, especially in the lower half. At least 70 feet of this rock are exposed without reaching the next underlying rock.

4. A mile and three-quarters northeast of the mouth of Fourteen-Mile Creek, on the land of James Beggs, a little stream known as Beggs' Run enters the Ohio River.

The *Corniferous* is exposed on the top of the hill west of the run.

Twenty feet below the Corniferous the *Charlestown lime rock* has been quarried for building stone. It is 20 feet thick. The broad form of *Pentamerus oblongus* is found.

The underlying (*Waldron shale*) clay is 10 feet thick.

The *Laurel bed* or *Cliff rock* consists, as usual in this part of the country, of brownish courses of an inferior limestone. Its thickness is at least 30 feet.

Beneath are thin courses of a more argillaceous limestone, with a total thickness of 10 feet, representing the *Osgood beds*. The Osgood limestone is not present here.

A hard siliceous layer of reddish brown color, immediately beneath, probably marks the horizon of the *Clinton*.

The eight feet of rock below the Clinton probably represent the upper part of the *Madison* beds. A layer of solid blue limestone at the lower part of this exposure contains *Orthis* (*Hebertella*) *occidentalis*, thus determining definitely its Lower Silurian Age. The Lower Silurian fossiliferous limestone is well exposed in the gully formed by Beggs' Run.

West of the run, on the north side of the road leading from the base of the cliff to the house at its summit, the Cliff, Niagara and associated rocks have been faulted, and the rocks on the southwest shoved over those on the northeast. Contortion and faulting is also noticed high up on the western side of the gully formed by Beggs' Run.

About one and one-half miles south of Charlestown, on the western side of the railroad, is a quarry and a cement mill.

The base of the *black shale* is exposed at the top of the quarry.

Five feet of a *Crinoidal limestone* occur immediately beneath.

Below this are one and one-half feet of a rock, the lower eight inches of which are *conglomeritic*. The pebbles are small and black, usually one-fourth inch, rarely one inch, in diameter. One limestone pebble, two by four inches, derived from the cement rock, was found. At North Vernon this layer contains fish remains. It is there found, however, below the cement rock, instead of above.

Nine feet of *Cement rock* are worked in the quarry. The cement bed contains pebbles composed of material similar to the cement rock itself.

Below the cement rock occurs the *Corniferous*. The Corniferous is exposed along a stream southeast of the depot at Charlestown. The precise interval between the base of the cement rock at the quarry and the top of the Corniferous along the stream is not known, but is small.

5. Along a branch of Lick Run, southeast of the depot at Charlestown, the *Corniferous* is exposed. Its thickness is 18 feet. Fossils, especially corals, are abundant.

The underlying *Niagara* is an argillaceous limestone of light brown color. Fourteen feet below the Corniferous *Halysites catenulatus* is found; 18 feet below the Corniferous *Strombodes pentagonus* occurs; *Heliolites* and

Favosites are found just beneath; 22 feet below the Corniferous *Astylospongia praemorsa*, with well-preserved spicules, is seen; 70 feet below the Corniferous the well-known mineral or lick spring comes out just where a small stream enters Lick Run. The rock at the spring unquestionably belongs to the *Laurel bed* or *Cliff rock* horizon. The clay bed marking the horizon of the Waldron shale is found higher up, but its level was not recorded. Within 50 feet of the lick spring there is a waterfall, the rock at its top being at nearly the same level as the spring. The upper layer at the fall is composed of quite hard stone. The lower layers are softer and have been much contorted and otherwise disturbed, giving rise to a gentle folding of the overlying hard beds, especially in the layer which forms the top of the falls. A part, at least, of the lower, softer, contorted brownish argillaceous rock must belong to the horizon of the *Upper Osgood clay*. The thickness of this softer rock is 22 feet. Beneath it is found the *Osgood limestone*, usually strongly brecciated and much and irregularly contorted, the dip being in places vertical, although the folds are only of comparatively small dimensions. *Pisocrinus gemmiformis* and *Stephanocrinus osgoodensis* are found in the limestone.

The clay layer below the Osgood limestone was not found exposed. At one point, considerably down the stream, the *Clinton* was found in immediate juxtaposition with the Osgood limestone, but evidently faulted together. The Clinton, where best exposed, is 26 inches thick. It is of a salmon-brown color and contains the following fossils: *Illaenus madisonianus*, *Phacops trisulcatus*, a species of *Bellerophon*, *Plectambonites transversalis* var. *elegantula*, *Leptaena* (*Strophomena*) *rhomboidalis*, *Strophomena* (*Strophonella*) *patenta*, *Orthis calligramma* var. *eu-orthis*, *Orthis* (*Platystrophia*) *biforata*, *Orthis* (*Dalmanella*) *elegantula*, *Clathropora frondosa*, *Phaenopora fimbriata*, *Pachydictya bifurcata*, *Pachydictya turgida*, *Rhinopora verrucosa*, *Cyathophyllum celator* var. *daytonense*, *Streptelasma obliquius*.

6. The *Madison beds* have been contorted with the other rock. A thickness of nearly 40 feet of the characteristic brown argillaceous rock of this series is exposed beneath the Clinton at one point along the run. This is the most southern exposure of the Madison beds identified with certainty.

At the base of this section of the Madison beds is found a layer of argillaceous blue limestone, with *Orthis biforata*, *Orthis occidentalis* and Lower Silurian bryozoa. A short distance farther down Lick Run Lower Silurian fossils are very common. The Lower Silurian limestones at this point have a very decided dip, nearly 30 degrees at one place.

The contortion of strata has evidently affected all the beds from the lower part of the Laurel bed or Cliff rock to the fossiliferous Lower Silurian limestones.

7. The road from Charlestown to Bethlehem crosses Fourteen-Mile Creek just below the mouth of Collins Run. The *Corniferous* is exposed near the upper part of the road west of Fourteen-Mile Creek.

Ninety feet lower down the *Clinton* occurs. The rock immediately above the Clinton is considerably contorted, but the exposures are not good. The general color of the Clinton is light red, but at the falls on Collins Run the upper portion of the Clinton is of a salmon-brown color, and contains *Orthis calligramma* var. *eu-orthis*, *Orthis* (*Platystrophia*) *biforata*, *Favosites niagarensis*, *Halysites catenulatus*, and *Cyathophyllum calyculum*. Farther east the salmon-brown phase of the Clinton is absent. At the falls the Clinton is two and one-half feet thick.

A *very fine grained white limestone* is found immediately below. This is the layer found associated with the Clinton at Charlestown Landing. It is of Lower Silurian age. Below the limestone are found 16 feet of the brownish argillaceous Madison rock, an impure limestone. It is very characteristic in color and appearance. The Lower Silurian rock immediately below the Madison contains several layers of limestone, with branching bryozoans These layers are exposed beneath the Madison beds along Lick Run, and they are exposed without the Madison beds at several points along Lick Run and in the gully west of the Charlestown Landing road, as already stated. Their thickness is 13 feet. Beneath are five feet of blue clay and then five feet of very fossiliferous limestone strata as far as the lower bridge across Collins Run. These very fossiliferous strata occur also along Lick Run. Their position is from 18 to 23 feet below the base of the Madison beds, as is shown by the Collins Run section.

8. The *Madison beds* are also exposed along the roadside east of Fourteen-Mile Creek. The Clinton here is difficult to recognize. It is white, usually fine grained rock, in places coarsely crystalline, about 15 inches thick, changing below into a drab-gray rock. But one fossil was found in it, *Cyclonema bilix*, with the last whorl showing only transverse striae. The Clinton at Begg's Run is somewhat similar to the Clinton here, where it is fine grained and very hard.

Above the Clinton lie about two and one-half feet of clayey shale and clay, a six inch course of limestone, and then perhaps more clay, occupying the horizon of the Osgood clay beds.

9. The road from Charlestown to New Washington crosses a small branch near the southern margin of the A. J. Carr farm. The Niagara immediately below the Corniferous contains *Halysites catenulatus* and *Cladopora*.

10. The Corniferous is exposed along the same road, up the hill southwest of the mouth of Ninepenny Branch. The upper Niagara is about 38 feet thick, the clay marking the Waldron shale horizon is about eight

feet thick, and the exposures down to the base of the hill measure about 60 feet. The lower part of the Upper Silurian is not seen.

11. On the hillside north of the Tunnel Mill the Upper Niagara is at least 20 feet thick. At its base it contains a crinoidal layer with *Atrypa reticularis* and *Caryocrinus*. The blue clay marking the Waldron shale horizon is well exposed and is eight feet thick. The Cliff rock or Laurel bed series beneath the clay is at least 60 feet thick. It resembles the Cliff rock as exposed near Charlestown Landing. It is an impure limestone and is not like the white, fine-grained limestone which marks this horizon northward.

B BULL CREEK.

12. On the western branch of Bull Creek, where crossed by the road a little over a mile south of Hibernia (southeast end of the Plasket farm), the Clinton is exposed in the bed of the stream. The Clinton is 32 inches thick, siliceous, whitish where fresh, brownish where weathered, in some places crinoidal.

Above the Clinton are 10 feet of blue shale, representing the lower Osgood clay bed; five feet of limestone, representing the Osgood limestone; about two feet of blue shale, representing the upper Osgood clay bed, and at least 20 feet of limestone, representing the Cliff rock or Laurel bed.

Below the Clinton is a 12-inch layer of a dark, blackish, sandy rock, with fucoidal markings; 21 feet farther down are sun cracks and poor ripple marks on one of the layers belonging to the Madison beds. Thirty feet below the Clinton one of the Madison bed layers contains *Orthis occidentalis* and Lower Silurian gasteropods. *Orthis occidentalis* occurs again 43 feet below the Clinton. The Madison beds are about 46 feet thick. Beneath them Lower Silurian fossils are common in the clay and the abundant thin limestone layers.

13. On the eastern branch of Bull Creek, where crossed by the road a mile and three-quarters southeast of Hibernia, there is an old mill on the former E. Stricker farm. The Clinton forms a low fall north of the road. Its thickness is 32 inches; it is usually siliceous and fine-grained, but in a few places varies to white and crinoidal.

Above the Clinton are 11 feet of blue, shaly rock, representing the lower Osgood clay, and containing near the top an *Orthoceras* like *O. amycus*, but more rapidly tapering; five feet of limestone broken up, called rubble stone, representing the Osgood limestone; five feet of blue, shaly clay, representing the upper Osgood clay; at least 25 feet of limestone, representing the Cliff rock or Laurel bed. A blue, clayey shale occurs 70 feet above the Clinton, and probably represents the Waldron shale horizon.

Below the Clinton are found eight inches of a black, fine-grained, sandy rock with fucoidal markings. Immediately beneath are 80 inches of siliceous rock closely resembling the Clinton above but merging into the Madison beds below. The bluish Madison beds are often full of vertical worm borings.

C. CAMP CREEK.

14. A short distance below the juntion of the two main forks of Camp Creek the Bethlehem–Hibernia road crosses over an iron bridge. Near the hill top west of the bridge the Clinton is exposed. It varies from 12 to 21 inches in thickness, both the upper and the lower surfaces are irregular; it is siliceous, brownish, fine grained, varying in places to coarser grained limestone.

Bluish shaly clay occurs above the Clinton, but its thickness was not observed.

Below the Clinton are found 12 inches of a light brown or grey stone, with *Tetradium minor;* seven inches of similar stone; one-fourth to one inch of very thin limestone with *Murchisonia hammelli*; three inches of brown limestone; 16 inches of dark brown or black, fine grained, sandy rock; limestone with *Leperditia cœcigena*, and *Orthoceras* at the top.

Twenty-seven feet below the Clinton the Madison beds contain *Orthis biforata* and *Orthis occidentalis.* Down to 40 feet beneath the Clinton the Madison beds are more commonly blue in color. Their total thickness is 47 feet. Fucoidal markings are common.

Below the Madison beds are found 37 feet of rock in which these highly fossiliferous limestones are interbedded with a greater quantity of clay. Below that level the limestones form a more important element of the Cincinnati group.

15. About a mile and a half northwest of the last exposure an east and west road crosses the west fork of Camp Creek. On this road, at the southwest end of the A. L. Waters farm, the Clinton is exposed 150 feet above the bed of the creek. It is siliceous, light brownish, and 28 inches thick

Below the Clinton are eight inches of black, fine grained, sandy rock with fucoidal markings; 10 inches of softer, brown limestone; 10 inches of limestone which is blue when fresh; 18 inches of shale with *Labechia ohioensis*; 34 feet of Madison bed rocks; thin limestone beds with abundant Lower Silurian fossils are found 43 feet beneath the Clinton, and lower down; the gasteropod bed, corresponding to the Marble Hill quarry bed, occurs 133 feet below the Clinton, and 86 feet below the Madison beds.

16. About two and one-half miles north of the last exposure, where the Otto-New Washington road crosses the west fork of Camp Creek, is

an old mill, now known as Kelly's mill. Not far down the creek is a dam, and soon after the ruins of a second mill are seen west of the creek. Just below the dam the Clinton is found. It is 8 to 18 inches thick. It is siliceous, light reddish brown, and contains *Orthis calligramma* var. *eu-orthis* and *Cyathophyllum calyculum*.

Above the Clinton there are 13 feet of blue, clayey shale, the shaly partings being fewer and the rock harder near the top. This shale corresponds to the lower Osgood clay. Above the clayey shale are found several feet of limestone. Further up the stream towards the bridge a blackish, clayey shale layer occurs, which is about three feet thick. It contains limestone lenses with *Camarotœchia* and crinoid heads, and is believed to represent the upper Osgood clay bed. About 34 feet of the Cliff rock or Laurel bed occurs above the blackish, clayey shale. It contains frequent specimens of *Calymene niagarensis* and used to be worked for these fossils. About 20 feet of clay above the limestone, west of the creek, along the road, are believed to represent the Waldron shale horizon. Near the top it is sparingly fossiliferous and the following fossils were found: *Atrypa reticularis*, *Camarotœchia neglecta*, *Spirifer eudora*, *Duncanella borealis* and *Stephanocrinus hammelli*. Above the clay six feet of limestone are found, representing a part of the lower beds of the upper Niagara.

17. On the road from Bethlehem to Otto, near the top of the hill just west of Bethlehem, the top of the Madison beds are easily recognized. The Clinton seems to be a siliceous, light brown rock, not a foot in thickness, but no satisfactory exposures were found.

Jefferson County.

D. Marble Hill, Saluda Creek, and Northwards.

18. From Marble Hill Postoffice a road leads down to the river landing. Turning off towards the right from this road, near the top of the hill, another road leads with very little change of level to some old quarries on the southern side of a deep ravine; a short distance beyond the road reaches the bluff above the Ohio River. The Clinton at the bluff measures 52 to 54 inches. It is siliceous, reddish brown, often coarse grained and difficult to distinguish from the Lower Silurian beds immediately below.

Above the Clinton are 12 to 15 inches of the basal Niagara limestone, of whitish color, then 12 feet of clay shale with *Orthoceras annulatum* and a cystidean near the top. This clay shale represents the lower Osgood clay. Above it lie five and one-quarter feet of limestone, formerly quarried for the manufacture of lime. This is believed to represent the Osgood limestone.

19. The road going due west from the north end of the cluster of houses at Marble Hill crosses a brook before reaching a school building. The limestone in the bed of this brook and for 10 feet up the hillside is believed to be the Cliff rock and the 10 feet of clay overlying the same is considered the representative of the Waldron shale, but the relation of these road exposures to the Marble Hill rocks was not carefully traced.

Below the Clinton, at the bluff above the Ohio River, lie seven feet of siliceous rock closely resembling the Clinton of this locality, but the color is more buff than reddish brown. Empty casts of crinoid stems are rarer, and it is softer. It is the top bed of the Lower Silurian. Rock of similar nature forms the top of the Lower Silurian two miles southeast of Hibernia at the southeast end of the Stricker farm, as already described, but at the latter locality the presence of the blackish rock with fucoidal markings makes the distinction between the Clinton and the Lower Silurian siliceous rock less difficult. Below the silicious rock are found three feet of thin brown shale, two and two-thirds feet of solid rock and about 48 feet of the Madison bed. The Madison bed is, however, so disintegrated below the bluff at the Ohio River front of the hill land that the lower part has the appearance of clayey shale or clay with occasional intercalated layers of limestone beds with few fossils. Abundant fossils make their appearance where the limestone layers become frequent, 60 feet below the Clinton.

20. The Madison beds are much better exposed along the road leading from Marble Hill down to the landing on the Ohio River. Bowlders from the gasteropod bed, once worked as a "marble quarry," occurred 80 feet below the Madison beds along this road. W. W. Borden, in his report on Jefferson county, estimates the thickness of the gasteropod bed at 20 feet.

21. About two miles north northwest of Marble Hill is the school house of District No. 2. The farm of Mart Payne lies at the end of a lane, directly north of the school. A small stream in the field northeast of the house runs northward to one of the many branches of Saluda Creek. The Clinton, as well as could be determined after a short search, was here siliceous, and about 16 inches thick. The precise separation of the Upper and Lower Silurian is difficult to determine.

Above the Clinton is a little rock; then one foot of blue clay; about two feet of stone; eight feet of blue clay; a total of about 12 feet of section, corresponding to the lower Osgood clay. Above this is limestone belonging to the horizon of the Osgood limestone. It contains *Pisocrinus gemmiformis* and *Pisocrinus benedicti.*

Below the Clinton the Madison beds occur in typical exposure, forming a steep grade, almost vertical in places, down which the stream rushes rapidly.

22. Going from school house No. 2 half a mile west, a quarter of a mile north, a quarter of a mile west, and then a mile north, the road crosses Saluda Creek just south of the house of Pinckney G. Swan. The Clinton can be recognized along the road side north of the creek crossing. It is light red, siliceous, weathering to an iron-stained brown. The upper 14 inches are without fossils, the lower 12 inches are more coarse grained and contain crinoid stems and *Cyathophyllum calyculum*, and some pebbles.

Above the Clinton are 10 to 12 inches of a whitish hard limestone; then 12 feet of blue clay, representing the lower Osgood clay. The Osgood limestone and the upper Osgood clay were not distinguished, though they may be present. The highest portion of the Cliff rock exposed is found 34 feet above the clay bed mentioned above.

Below the Clinton is found a decidedly clayey stone, and then the Madison bed. The Madison bed is probably 54 feet thick, the limestone beds becoming common at this distance below the Clinton. The gasteropod bed is found 60 feet below the Madison bed, and 50 feet farther down is the bed of Saluda Creek.

23. Going from the house of Pinckney G. Swan one mile northward and nearly a mile westward, the residence of D. P. Monroe is reached. A small stream flows directly south from his house towards Saluda Creek. A short distance before joining the creek it falls over a high fall, known as the Dog Falls. The Clinton is here 46 inches thick. The upper part of the Clinton is whitish with blotches of salmon-brown color. The main portion is salmon-brown. The lower four inches are in places white and fine-grained. The locality is not more fossiliferous than many others where the salmon-brown Clinton occurs, but more time was spent in collecting here, and, therefore, the list of species found in the Clinton is larger.

Illœnus daytonensis, *Illœnus ambiguus*, *Calymene niagarensis*, and *Dalmanites wertheni*. In the white limestone at the bottom of the Clinton were found *Lichas breviceps*, and an unknown Ostracod, *Bellerophon fiscellostriatus*, *Cyclonema "bilix,"* the Clinton species, *Plectambonites transversalis* var. *elegantula*, *Leptœna (Strophomena) rhomboidalis*, *Strophomena hanoverensis*, *Strophomena patenta*, *Orthis calligramma* var. *dinorthis*, *Orthis (Platystrophia) biforata*. In the white part of the Clinton at the bottom were found *Atrypa marginalis*, *Clathropora frondosa*, *Phœnopora expansa*, *Phœnopora fimbriata*, *Phœnopora ensiformis*, *Pachydictya bifurcata*, *Pachydictya turgida*, *Rhinopora verrucosa*, *Lioclemella ohioensis*, *Hemitrypa ulrichi*, *Heliolites subtubulatus*, and *Cyathophyllum calyculum*.

Above the Clinton are found 32 inches of the whitish basal Niagara limestone. Above this is a shaly rock, representing the lower Osgood clay. No attempt was made to distinguish the Osgood limestone or the upper Osgood clay. The base of the Cliff rock lies 20 feet above the

basal Niagara limestone. Fourteen feet of Cliff rock or the Laurel bed are exposed near the falls.

Below the Clinton are found eight inches of rock with Ostracoda, *Entomis madisonensis*, *Leperditia cœcigena*, *Eurychilina striato-marginata*; two inches of limestone with *Orthoceras*, *Nucula* and other fossils corresponding to the *Murchisonia hammelli* layer on the Hitz's road near North Madison. Below are eight inches of hard, brown limestone, two inches of limestone with *Orthoceras*, *Nucula* and *Labechia ohioensis*. At the fall 30 feet of the Madison bed are exposed. *Orthis biforata* and *Orthis occidentalis* occur in hard, brown, impure limestones at several levels in the lower 10 feet of the series. The top of the Lower Silurian limestones, with abundant limestone layers, is found 60 feet below the Clinton. The junction of the Dog Falls stream with Saluda Creek is 20 feet lower down.

24. Half a mile west of Dog Falls is found the junction of the two main branches of Upper Saluda Creek. The rocks dip low eastward in this region. Both branches form falls over the Clinton rock within a short distance of their junction, and both have formed typical pot-holes in the Madison bed below. The northern branch has formed 21 of these, in rows across the stream, locating the former position of the falls. The Clinton is salmon-brown and 45 inches thick. About 12 feet of clayey limestone, with thin courses, overlie the Clinton, and correspond to the Lower Osgood clay. Limestone is found above.

Fifteen feet below the Clinton, wave marks occur in the Madison bed. Their trend is north and south. The lower half of the Madison bed contains impure limestone layers, with fossils at various levels. The junction of the Madison beds with the very fossiliferous limestone series at their base is well shown in the cliff opposite the mouth of the creek forming Dog Falls.

25. Following the road from D. P. Monroe's house a little over a mile eastward, the road turns southward and eastward again, reaching the house of Wallace Horrell, just beyond a small stream. From this point eastward, down the hill, the roadside exposes the section to be described. The Clinton is 10 to 12 inches thick; it is siliceous, slightly reddish, and could not be recognized if the accompanying overlying and underlying rocks were not exposed.

Above the Clinton are 10 inches of a clayey stone, and then 12 feet of blue clay shale and rubble stone, corresponding to the Lower Osgood bed and containing a *Strophomena*, related to *Str. patenta*, but with much coarser striations, *Pentamerus oblongus*, and a *Spirifer*, related to *Sp eudora*. Above the clay occur several layers of rock corresponding to the Osgood limestone. It is recorded in my notes as being siliceous, but seem to remember it as being crinoidal in some of its layers. Cherty

beds occur above the white limestone, 50 feet above the Clinton. The white limestone belongs at the top of the Laurel limestone.

Below the Clinton are found four inches of light green, clayey rock, a dark brown layer eight inches thick, with very poor specimens of *Murchisonia*, a 12-inch layer of clayey stone with *Labechia ohioensis*, and then a thin layer with *Murchisonia hammelli*, *Holopea hubbardi*, and other fossils. The Madison bed is 65 feet thick. The gasteropod bed, corresponding to the Marble Hill quarry rock, occurs 80 feet below the Madison bed.

26. At the foot of the hill east of Wallace Horrell's farm, an old road leads northward, and within half a mile crosses a creek. From the creek to the top of the hill, at the residence of John Bair, there is quite a continuous exposure of rock. The Clinton is found near the top of the hill. It is reddish, weathers brownish, is irregularly bedded, and varies from 12 to 16 inches in thickness.

Above the Clinton are found eight inches of the white basal Niagara limestone, and 8 to 10 feet of blue clay, representing the Lower Osgood clay.

Below the Clinton is found a clayey, indurated stone, 22 inches thick; then four inches of clay with *Labechia ohioensis*, two inches of limestone, with *Murchisonia hammelli*, and an annulated *Orthoceras*. The Madison bed is about 45 feet thick. In the lower 10 feet are several layers of impure limestone with *Orthis occidentalis* and other fossils. The gasteropod bed, corresponding to the Marble Hill quarry rock, occurs 85 feet below the Madison bed.

E. HEARTS FALLS TO HANOVER AND CLIFTY FALLS.

27. From the Bair farm half a mile northward, half a mile westward, and then two-thirds of a mile northward, the road crosses a creek which a short distance farther down stream forms Hearts Falls. The Clinton is here 30 to 32 inches thick, and of salmon-brown color. Cherty beds occur in the Cliff rock, 43 feet above the Clinton. A clay bed occurs 47 feet above the Clinton and is believed to represent the Waldron shale.

28. Going from Hearts Falls a mile westward and nearly as far northward, a road leads eastward to the Chain Mill Falls, half a mile distant. The Clinton is here 50 to 52 inches thick, has a salmon-brown color, and is fossiliferous, but only *Orthis calligramma* var. *eu-orthis* and *Rhinopora verrucosa* are recorded.

Above the Clinton occur 22 inches of solid limestone, the basal Niagara; then six feet of shaly rock representing the Lower Osgood clay.

Immediately below the Clinton is rock with Ostracods. The layer with *Murchsonia hammelli* occurs 60 inches below the Clinton. The falls give a fine exposure of the Madison bed.

29. Two-thirds of a mile north of the Chain Mill Falls is Butler's Fall. The Clinton is exposed nine feet above the top of the falls. It is 27 to 29 inches thick, and is of salmon-brown color.

Above the Clinton are about 12 feet of a clayey rock, quite indurated, often broken up and rubbly, representing the Lower Osgood clay. Twenty-two feet higher up, on the road to Hanover, occurs the stone quarried for Science Hall of Hanover College. About seven feet of good quarry stone are found here, but the quarry has not been properly opened. Blue clay is found about 45 feet above the Clinton, west of the Hanover road. It is believed to represent the Waldron shale. The rock quarried for the Science Hall is therefore a member of the Cliff rock, or Laurel bed. Flinty layers occur near the top. Below the Clinton is found a layer with *Leperditia cœcigena*, 16 inches below the Clinton, *Labechia* occurs. The upper 20 feet of the Madison bed at the falls are composed of firmer, harder rock, and project beyond the lower, softer part.

30. Two-thirds of a mile north of Butler Falls, and directly south of the end of the Madison-Hanover Pike, are found the Crow Falls. The Clinton is here 16 inches thick, and contains *Orthis calligramma* var. *eu-orthis*, *Orthis* (*Platystrophia*) *biforata*, *Plectambonites transversalis*, var. *elegantula*, *Strophomena hanoverensis*, *Phaenopora ensiformis*, and *Rhinopora verrucosa*. Bluish rock with *Labechia* occurs four inches beneath the Clinton.

31. Soon after entering the grounds of Hanover College a path turns off towards the right and leads to a spring along the old, and now abandoned, Hanover Landing road. A water trough formerly stood at this point. The Clinton is here 36 inches thick. *Labechia* is found one foot below the Clinton. Along the new Hanover Landing road, a short distance away, the Clinton is only 17 inches thick.

Above the Clinton there is a considerable exposure of rock not carefully examined. The white limestone has been quarried near the junction of the Hanover Landing with the Hanover College road. The white limestone contains *Calymene niagarensis*, and near the top, 50 feet above the Clinton, it has cherty layers interbedded. The white limestone is believed to belong to the Cliff rock or Laurel bed horizon.

32. The base of the Corniferous occurs 40 feet higher up, in the bed of a small stream just west of the house of Prof. Culbertson.

33. Below the Clinton, on the Hanover Landing road, is the *Leperditia* layer, eight inches thick; then a fossil layer 17 inches thick with *Murchisonia hammelli*, *Orthoceras* and *Leperditia*. The Madison bed is 47 feet thick. *Favistella stellata* occurs near its base. The richly fossiliferous Lower Silurian limestones occur below the Madison beds, and thence down the hill.

34. Two-thirds of a mile northeast of Hanover College, on the road leading south from school house, District No. 6, the Clinton is 12 to 13

inches thick. Above the Clinton occurs a clayey, rubbly rock 15 feet thick, representing the Lower Osgood clay. The white limestone is exposed farther up the road, and a cherty bed occurs near the upper part, 45 feet above the Clinton.

Below the Clinton occurs the Madison bed. The fossiliferous Lower Silurian limestones become abundant 60 feet below the Clinton.

35. A mile northeast of the last locality, at the water-trough on the Madison-Hanover pike, the Clinton is 18 inches thick. It is salmon brown in color.

Above the Clinton is the solid, basal Niagara limestone, eight inches thick. Farther up is a clayey, rubbly material, nearly 10 feet thick, representing the Lower Osgood clay. A brown, impure limestone layer, 15 inches thick, seems to represent the Osgood limestone. The Cliff limestone is exposed 32 feet above the Clinton; 16 feet are visible, and the lower part is evidently not exposed.

A bluish, solid rock, with *Leperditia cæcigena* is found just beneath the Clinton.

36. A mile and a half west of Madison, the Madison–Hanover pike crosses Clifty Fork. Two miles up the stream occur the Clifty Falls. In the bed of the stream above the falls the Clinton is exposed. It is 11 inches thick. The upper portion is siliceous and light, reddish brown, and contains no fossils. The lower two to four inches are white and coarse-grained in some localities; it here contains a fairly abundant fauna—*Orthis calligramma* var. *eu-orthis*, *Plectambonites transversalis* var. *elegantula*, *Phænopora expansa*, *Pachydictya bifurcata*, *Pachydictya turgida*, *Pachydictya obesa*, *Rhinopora verrucosa*, *Heliolites subtubulatus*, *Cyathophyllum daytonense*.

Above the Clinton are found six to eight inches of the basal Niagara. The lower 28 inches of the clayey layer above are quite hard and indurated. Above this clay layer (not measured) there are four feet of limestone and three feet of clay, representing the Osgood limestone and the Upper Osgood clay. Twenty-four feet of Cliff limestone are exposed above the upper clay.

Below the Clinton is a bluish rock, with *Labechia*.

F. MADISON AND CROOKED CREEK.

37. Immediately west of the railroad track, at the west end of Madison, the Hitz Road, a private roadway, leaves the pike and ascends the hill toward the northwest. The locality was carefully examined in company with Mr. J. F. Hammell, of Madison, a well known geologist in these regions, and the collector of many new species of fossils in Jefferson County, described in the Indiana and other reports.

The Clinton varies from 15 to 22 inches in thickness. Its color is reddish, varying in places toward light brown. It contains a few pebbles,

the largest measuring one and one-half, by one, by one-half inches. The fossils were few: *Orthis calligramma* var. *eu-orthis*, *Plectambonites transversalis* var. *elegantula*, *Pachydictya bifurcata*, *Heliolites subtululatus*, *Cyathophyllum calyculum*.

Above the Clinton are 10 feet of clayey rock, representing the Lower Osgood clay, 55 inches of limestone with several clay partings representing the Osgood limestone or Cystidean bed, and seven feet of material which is chiefly clayey and rubbly rock. The Osgood limestone, with that portion of the clay layers immediately above and below it, is the horizon of the famous Cystideans of Jefferson County. Nearly 10 feet of Cliff rock are exposed.

Immediately below the Clinton, *Byssonychia radiata* is found; below are 16 inches of light brown rock, with worm-borings; nine inches below is a nine-inch layer of bluish rock, with *Murchisonia hammelli*, *Holopea hubbardi*, and *Labechia;* just beneath *Orthis occidentalis* and branching bryozoa are found. The Madison bed is banded with light brown and purplish brown for 30 feet, then, farther down, 30 inches of shale, 11 inches of blue, clayey rock, and 54 inches of shale intervene before the first bed of *Favistella stellata* is reached, 40 feet beneath the Clinton.

38. East of the railroad the pike to North Madison presents a fine exposure of the Madison bed at the Hanging Rock. Farther up the road the Clinton is exposed. It is 22 inches thick. Its color is light red tinged with brown, but in places it is a little salmon-brown. The fossils are *Strophomena hanoverensis*, *Atrypa marginalis*, of the Brown's quarry type; *Rhinopora verrucosa*, and *Heliolites subtubulatus*.

Above the Clinton are eight inches of hard rock, like the siliceous Clinton, but more white in color; then eight inches of light brown rock, the basal Niagara; 11 feet of soft, clayey rock, corresponding to the Lower Osgood clay; above, it passes into a limestone which corresponds to the Osgood limestone. In the railroad cut a shale layer is seen above this limestone, and then the Cliff rock or Laurel bed comes in.

Below the Clinton, 16 inches, is a thin layer with *Murchisonia hammelli*, *Holopea hubbardi* and *Orthoceras*; 16 inches farther down *Orthis occidentalis* and numerous branching bryozoa occur. The Madison bed is well exposed. A short distance below its typical exposure the *Favistella stellata* bed occurs, and some distance lower the Cincinnati group limestones are common.

39. On the Michigan road the Clinton is 21 inches thick; it is siliceous and of a light, reddish brown. Above it is a drab transition rock 10 inches thick, similar to the layer described on the North Madison pike above the Hanging Rock. Above this lies an eight-inch layer of the undoubted basal Niagara.

Eight inches below the Clinton is a layer with *Murchisonia hammelli;* 16 inches below, the dark top of the Madison beds come in.

The following notes, published in the Indianapolis *Journal* for May 10, 1874, and kindly sent to me by Dr. W. T. S. Cornett, will be of service in comparison with other observations taken farther southward as well as near Madison. Immediately beneath the Clinton were found the following Lower Silurian fossils: *Orthis* (*Platystrophia*) *biforata*, var. *acutilirata*, *Orthis* (*Hebertella*) *occidentalis*, *Murchisonia milleri*, *M. bellicincta*, *Orthoceras junceum*, *Cyrtoceras sp.*, *Byssonychia radiata*. *Monticulipora frondosa*, *M. mammulata*, and *Batostomella* (*Chaetetes*) *gracilis*. In addition to this list, Mr. E. T. Cox published: *Orthis retrorsa*, *O. subquadrata*, *O. insculpta*, *Strophomena planumbona*, *Str. sulcata*, *Rhynchotrema capax*, *Rh. dentata*, *Zygospira headi*, and *Streptelasma corniculum*. These fossils occur in the layer immediately beneath the Clinton, and also in a thin layer lying 18 inches below the Clinton. Below this point lie 32 feet of nonfossiliferous rocks rapidly disintegrating or weathering, called in this report the Madison rocks. At their base some of the layers show sun cracks and ripple marks. Beneath the Madison rocks fossils are again common, the species being practically the same as those found above the Madison beds, mentioned in the preceding list. About seven and one-half feet below the Madison beds *Tetradium minor* occurs, the same fossil occurring again one and one-half feet farther down. Six feet below the last layer *Favistella stellata* is very common, and forms a well marked horizon 49 feet below the base of the Clinton. Two feet below the *Favistella* layer, or 302 feet above low watermark on the Ohio River a third layer of *Tetradium* occurs.

The thickness of the Clinton is not given in the Cornett section. According to my measurements it is 21 inches, in addition to which there are 10 inches of transition rock immediately above it. The combined thickness of the Clinton and the lower Niagara, up to the base of the more solid Cliff or Laurel beds of the Niagara, is 23 feet. The Cliff Niagara has a thickness of 13 feet; it is overlaid by 11 feet of a white limestone containing fossils, and this in turn by five feet of a bluish limestone containing *Pentamerus oblongus*. The upper rocks I did not see in my section along the Hitz road.

40. The Canaan road follows the valley of Crooked Creek. About two and a half miles north of Madison the Graham road branches off towards the northwest, and half a mile farther on it passes by a falls on the land of Mr. King. The Clinton is exposed near by, on the roadside. It is 18 to 23 inches thick, and of salmon brown color, except at the very top, where it is siliceous and of reddish brown color.

Above the Clinton lies the basal Niagara limestone, nine inches thick; then five feet or more of unexposed rock, five feet of impure limestone; and an unmeasured thickness of rock, resembling the Cliff rock. The upper part of the section needs further study.

Below the Clinton is one foot of bluish rock; then a clayey layer with *Labechia*; next, a blue rock again. Both blue rocks contain *Murchisonia hammelli*; *Byssonychia radiata* and an *Orthoceras*. The typical banded, reddish brown and greenish blue Madison bed is 35 feet thick. Below, the rock is similar in nature, but softer. It contains fossils at the base of the typical Madison rocks, and two feet farther down. A *Favistella* layer occurs eight feet, and another 12 feet below the base of the typical Madison rocks. The abundantly fossiliferous Cincinnati group limestone beds come in 65 feet below the Clinton.

41. The Canaan road, after passing the junction with the Graham road, ascends the hill toward the northeast. The Clinton is here 23 inches thick. The color is salmon-brown. The Cliff Niagara begins 30 feet higher up.

The typical Madison bed is about 30 feet thick. Shaly beds with limestone layers are found beneath it. They contain Lower Silurian fossils three feet below the typical Madison beds. The upper *Favistella* bed occurs 43 feet, and the lower 47 feet, below the Clinton, among layers of limestone full of Lower Silurian fossils.

42. The pike from Madison to Manville ascends the valley of the most southern branch of Crooked Brook. About one mile from Madison, at a bend in a road, there is a gully on the north side of the road. The Clinton at the top is six to seven inches thick. Its color varies at different places from siliceous and light brown to coarser grained and salmon brown. It contains *Illaenus ambignus* and *Pachydictya turgida*. It is overlaid by four inches of a siliceous, very light brown rock. Above it are eight inches of grayish basal Niagara limestone.

Twenty-four inches below the Clinton is a dark blue bed with *Murchisonia hammelli* and *Orthoceras;* 33 inches below the Clinton a similar bed contains also *Labechia* and bryozoa. The Madison beds are 34 feet thick. *Orthis occidentalis* occurs near its base. A lithologically similar shaly material below the typical Madison beds contains frequent fucoidal markings.

G. LONESOME HOLLOW. EAGLE HOLLOW.

43. About half a mile in a direct line across the country south-southeast of the last locality, at the northern end of Lonesome Hollow, on the west side of John B. Cochran's farm, a roadway leading southward exposes the Clinton. It is eight inches thick and is overlaid by 20 inches of rock, which is a transition rock between it and the basal Niagara above. Overlying the latter are 14 feet of clay representing the Lower Osgood clay, three feet of limestone with *Pisocrinus gemmiformis*, representing the Osgood limestone, and then clay again—the Upper Osgood clay.

44. At the north end of Eagle Hollow, on the road south of the Ryker's Ridge Baptist Church, the Clinton is 28 inches thick. It is chiefly siliceous and reddish brown in color, and is overlaid by eight inches of basal Niagara. The Lower Osgood clay and the Osgood limestone, with *Pisocrinus*, occurs, but was not measured.

45. A mile southeast of the church is a tollgate. The Madison rock is well exposed a quarter of a mile west of the same.

H. PLEASANT RIDGE AND RIKER'S RIDGE.

46. A road follows the main valley of Bee Camp Creek. Within a hundred feet of its junction with the Pleasant Ridge pike there is a fine exposure. The Clinton is here 13 inches thick. It is siliceous and light reddish brown.

Above the Clinton lie six inches of whitish basal Niagara limestone.

The Madison beds are banded with brown and gray green, and are about 40 feet thick. Below the Madison bed is a clayey shale with dark fucoidal markings, 18 feet thick. At various levels it contains thin limestone layers; one of these, three feet above the base, contains *Strophomena sinuata.*

47. A little over half a mile eastward, in a gully east of the Pleasant Ridge Church, the Clinton is eight inches thick. It is siliceous and of a light reddish brown color. Above it are fifteen feet of clayey shale, then three to four feet of limestone and blue clay again, representing the Lower Osgood clay, the Osgood limestone and the Upper Osgood clay.

48. Half a mile south of the church, on the Pleasant Ridge road, the Clinton is fourteen inches thick. It is silicious, and of a light reddish brown color. Above it are six to eight inches of basal Niagara limestone, of light drab color.

49. At the western end of Wolf Run, near the head waters of the stream, northeast of the Ryker's Ridge Baptist Church, an exposure is found on the northern side of the stream. The Clinton is 34 inches thick; it is light brownish and contains numerous angular fragments and lenses of a whitish rock.

Above the Clinton are eight inches of basal Niagara limestone, 14 feet of clayey rock, the Osgood clay; four feet of limestone, the Osgood limestone, and an upper clay layer, the Upper Osgood clay.

A short distance below the Clinton is *Leperditia cœcigena.* The Madison bed is exposed farther down.

50. The Ryker's Ridge road goes from the Baptist church half a mile northward, and then eastward to the house of James H. Carr. In a small run north of the house the Clinton is exposed. It is reddish brown, 24 inches thick, and near the top contains fragments and lenses of a grayish rock.

Above the Clinton lie 16 feet of clay, the Lower Osgood clay, five feet of a hard limestone, much weathered, the Osgood or Cystidean limestone, and then four feet more of clay with numerous fossils, the Upper Osgood clay. The upper clay contains *Platystoma niagarensis, Leptaena rhomboidalis, Atrypa reticularis, Anastrophia internascens, Camarotœchia indianensis, Rhynchotreta cuneata* var. *americana, Whitfieldella nitida, Spirifer eudora* and *Spirifer crispus.*

51. Northwest of Carr's house, on the west side of the ridge road, behind an orchard, the same section is exposed.

I. WESTERN BRANCH OF INDIAN-KENTUCK.

52. At the head of Schnapps Creek, or Comb's Run, east of the Canaan road, along a road following the valley, the Clinton is 20 inches thick. It contains angular masses and lenses of a whitish rock. The fossils are *Orthis calligramma* var. *eu-orthis, Orthis (Platystrophia) biforata, Strophomena hanoverensis, Strophomena patenta,* and *Rhinopora verrucosa.*

Above the Clinton are 10 inches of basal Niagara; 14⅓ feet of clay, four feet of limestone and five feet of clay, the Osgood series, covered with more limestone.

53. A road traverses the length of the ridge north of the Schnapps Creek valley. A mile east of the Canaan road church the Clinton is 24 inches thick.

54. Half a mile north of the church just mentioned, on the Canaan road, the Clinton is 25 inches thick, and contains lenses of white stone. The fossils are *Plectambonites transversalis* var. *elegantula,* and *Orthis elegantula* var. *parva.*

Below the Clinton is a blue clayey limestone. About five feet below the Clinton *Ostracoda* are common; six feet below the Clinton, ripple marks occur. Though distinct, the ridges are only two inches apart and run N. 50 E.

55. The various larger forks of Razor Creek all form considerable falls over the Madison bed. The most northerly branch of the creek forms a fall a short distance east of the Graham road, southeast of the house of Mr. Geisler. The Clinton at this point is 23 to 25 inches thick and has a salmon-brown color.

A short distance above the Clinton there is a clay bed. The base of the Cliff Niagara is about 25 feet above the Clinton.

Below the Clinton are 25 inches of a siliceous fine-grained rock, whitish or tinged with brown; 12 inches of clay rock with *Labechia*; a bluish rock with *Murchisonia hammelli, Byssonychia radiata* and *Orthoceras.* A similar rock occurs three feet lower down. Three feet lower, the top of the falls is found. The upper part of the Madison bed is composed of whitish rock, similar to the Belle-view exposure.

56. Going a mile south of Mud Lick or Belle-view and then a mile eastward, the farm house of Stephen Aich is reached. South of the road the Clinton is exposed in the bed of the brook. It is light red and four inches thick, becoming eight inches thick northeastward in the road bed.

Above the Clinton are three inches of basal Niagara limestone, 13½ feet of the lower Osgood clay, 38 inches of Osgood or Cystidean limestone, four feet of the upper Osgood clay and the lower part of the Cliff rock.

Below the Clinton are 14 inches of dark blue rock with *Leperditia caecigena*, five inches of similar rock, six inches of bluish rock with *Murchisonia hammelli*, *Holopea hubbardi* and *Orthoceras*; 50 inches farther down *Labechia* occurs in a clayey bed.

57. Nearly a mile north of Belle-view, just before reaching a road corner with a grist mill, a stream passes beneath an arched stone culvert. A short distance eastward it joins another stream, and a short distance farther the united stream falls over a small exposure of the Clinton. The Clinton is 33 inches thick. It is chiefly of salmon-brown color, but some light brown and a few very dark brown layers were found. It contains the following fossils: *Proetus determinatus*, head and pygidium, *Illaenus daytonensis*, *Illaenus ambiguus*, *Illaenus madisonianus*, head and pygidium, *Calymene niagarensis*, *Lichas breviceps*, *Pterinea brisa?*, *Bellerophon fiscellostriatus*, *Platystoma niagarense*, *Plectambonites transversalis* var. *elegantula*, *Orthis calligramma* var. *eu-orthis*, *Orthis* (*Platystrophia*) *biforata*, variety with three median dorsal plications, *Orthis* (*Dalmanella*) *elegantula*, *Leptaena* (*Strophomena*) *rhomboidalis*, *Strophomena hanoverensis*, *Strophomena* (*Strophonella*) *patenta*, *Strophomena tenuis*, Clinton precursor, *Ptilodictya whitfieldi*, *Clathropora frondosa*, *Phaenopora fimbriata*, *Rhinopora verrucosa*, *Aspidopora parmula*, *Favosites niagarensis*.

Above the Clinton is the basal Niagara; then about eight feet of clay rock, turning near the top into a sort of rubble stone, representing the Lower Osgood bed. The Osgood limestone and the layer of blue clay above the same are also represented here, but not in very typical form. A considerable exposure of Cliff rock occurs along the upper part of the creek.

Below the Clinton are 12 inches of greenish blue, clayey rock, soft above, harder below, without fossils, 10 inches of blue limestone, fine-grained, with abundant *Leperditia cœcigena*; eight inches of bluish limestone with deep brown, sandy courses, or lenses, of very irregular outline. Beneath this the upper 20 feet of the Madison beds occur, but their appearance is unusual, the rock being usually a white limestone, instead of an argillaceous banded rock. The blue phase with *Murchisonia hammelli*, *Holopea hubbardi* and *Orthoceras* occurs 10 feet below the Clinton, and layers with *Leperditia* occur at quite a number of levels. The typical banded Madison rock is found at the lower falls quite a distance down the stream, where 15 feet of typical Madison rock

are exposed. The richly fossiliferous Cincinnati limestones are found farther down along the branch into which the stream just followed empties.

58. In the northeast corner of Monroe Township, a mile and a half north of Bryantsburg, a road leads from the Michigan pike a mile eastward to the western fork of Indian-kentuck Creek. A quarter of a mile farther east it crosses a branch of the creek. Just above the bridge the Clinton is exposed in the branch. It is 12 inches thick, of a light brown color, and contains *Halysites catenulatus*. The locality was visited in company with Mr. J. F. Hammell, who succeeded in recognizing his Cystidean beds in the section.

Above the Clinton are the basal Niagara, six inches thick, and three feet of rock and clayey shale similar to the basal Niagara. Above it are eight feet of clayey shale without fossils, the Lower Osgood clay, and eight inches of a soft, clayey shale. Mr. J. F. Hammell informs me that this upper clay is the lowest level at which he has found his Niagara Cystideans. Twenty-four inches of indurated clay rock contain, according to Mr. Hammell, most of the Cystideans. At our visit two Cystideans were found *in situ*. Thirty-eight inches of limestone, with intercalated clay partings occur here. The limestone contains various brachiopods, and is the Osgood limestone. Cystideans are often found on the upper or lower surface of the limestone layers, partly exposed, but can not be freed from the rock. Occasionally Cystideans are found free in the clay partings between the limestone. Twenty-four inches of clay next follow and forms the highest level at which Cystideans were found by Mr. J. F. Hammell, although none were found by us. Six feet of clay shale, the Upper Osgood clay, succeed, followed by the Cliff rock or Laurel lime stone.

The locality here described is not a rich Cystidean locality, but stratigraphically, the beds which along Big Creek carry the Cystideans were also present here, and the information of Mr. Hammell made it possible to locate the position of the Cystidean beds in the Osgood series very accurately.

59. A quarter of a mile south of Canaan a road turns westward, and within a mile and a half reaches an exposure of the Clinton, where the road descends one of the upper branches of the Dry Fork Valley. The Clinton is 21 inches thick, has a salmon-brown color, and contains masses of a whitish rock. The fossils are *Illaenus daytonensis*, *Plectambonites transversalis* var. *elegantula*, *Leptaena* (*Strophomena*) *rhomboidalis*, *Strophomena* (*Orthothetis*) *tenuis*, Clinton precursor, *Strophomena patenta*, *Camarotœchia scobina*, *Clathropora frondosa*, and *Rhinopora verrucosa*.

Above the Clinton the Lower Osgood clay, the Osgood limestone, the upper Osgood clay and the Cliff rock may be recognized. The flinty rock near the top of the Cliff rock is found 50 feet above the Clinton.

Wave marks occur in Dry Fork 85 feet below the Clinton. The ridges run N. 70 W., and are about 20 inches apart.

60. The Clinton is exposed on the Madison-Canaan road, half a mile northeast of its crossing over the west fork of Indian-kentuck Creek. *Favistella stellata* is very common at its proper horizon farther down the hill.

J. HALL'S RIDGE TO CANAAN AND THE COUNTY LINE.

61. A considerable thickness of Clinton, as nearly as I can remember about 30 inches (not recorded), was exposed about a mile south of Canaan, where the road descends into a deep valley and turns eastward. It is again exposed where the road ascends the opposite side of the valley and continues as the Hall's Ridge road.

62. At the most southern outcrop on Hall's Ridge the Clinton is 32 inches thick, and has a salmon-brown color.

63. On the eastward extension of Hall's Ridge, on the land of Ab. Rogers, the Clinton is poorly exposed in the roadway. The thickness is at least 12 inches.

64. On the White-eye Hill road, a mile southeast of Canaan, the Clinton is 12 to 15 inches thick, has a reddish-brown color, and contains fragments of a whitish rock. Above it are six inches of basal Niagara limestone, 14 feet of the lower Osgood clay, 50 inches of the Osgood limestone, and the upper Osgood clay.

65. The Clinton is exposed at several points on the road east of Canaan. Directly north of Canaan, at the edge of town, it is exposed in a ravine. The Clinton is here 36 inches thick, and varies from light reddish brown to salmon brown in color. The various Osgood beds are also well exposed.

66 Going from Canaan, a third of a mile westward and two miles northward, a stream is crossed just before reaching a school house and church. West of the road the Clinton is exposed in the bed of the stream. It is thirty-three inches thick and has a salmon brown color.

67. A mile further north, just north of the Jefferson County line, a stream crosses the road, and a short distance east of the same it exposes the Clinton. The Clinton is 47 inches thick, and has a salmon brown color. Lenses of a whitish rock are not uncommon at various levels. The fossils are *Illaenus daytonensis*, *Illaenus ambiguus*, *Orthis calligramma* var. *euorthis*, *Strophomena hanoverensis*, *Strophomena patenta*, *Clathropora frondosa*, *Phaenopora fimbriata*, and *Rhinopora verrucosa.*

Above the Clinton are six inches of the basal Niagara limestone; 11½ feet of the Lower Osgood clay; 30 inches of the Osgood limestone, with *Pisocrinus gemmiformis;* four feet of the Upper Osgood clay, and a considerable thickness of the Cliff rock or Laurel bed.

K. BARBERSVILLE AND NORTHEASTERN CORNER OF COUNTY.

68—69. The Clinton is well exposed southwest of Barbersville, and at various points along the road from Barbersville to Hicks' Postoffice, where the road takes a southwesterly course before reaching Hicks' Postoffice.

70. Precisely four miles east of Canaan, in a direct line, is a school house on an east and west road. A short distance eastward a light red limestone about eight inches thick, presumably a portion of the Clinton limestone, is exposed in the roadbed. Farther eastward the Lower Silurian is exposed, with *Leperditia caecigena*, *Murchisonia hammelli*, *Orthoceras*, and a lamellibranch.

71. Towards the southeast, in the bed of a dry run, a light, reddish-brown rock was seen, which may occupy the Clinton horizon, but it was impossible to identify its horizon with certainty. About a third of a mile westward a few salmon-brown Clinton bowlders were seen.

72. Two miles directly northward, on Poplar Ridge, there is another school house at a road angle. A third of a mile eastward the road turns northward, and west of the road, while digging a well, about 30 inches of a reddish-brown rock were struck, similar to the dry run exposure just mentioned. This may also represent the Clinton horizon.

L. PARIS CROSSING.

Paris Crossing.—Nine miles southwest of Dupont, on the railroad leading from North Vernon to Louisville, is Paris Crossing. The Devonian crinoidal limestone is exposed half a mile south of the village, on the western side of the railroad; about five feet are exposed. The cement rock, a blue, fine-grained stone, of value commercially near Charlestown and southward, is about three feet thick. The Corniferous is exposed down to the level of the railroad track, five feet, but its total thickness is about seven feet or a little more. The Upper Niagara, a dolomitic limestone, is about 25 feet thick. It is exposed along the banks of Graham Creek, east of the railroad. A short distance southward the railroad crosses a road by means of a trestle. This point is called the Under-cut. Opposite the Under-cut, the lower banks of Graham Creek expose about five feet of Waldron shale, full of fossils. These fossils have been collected chiefly by collectors living in Hanover, Indiana; the collectors have obtained at this point a large part of the fossils first cited from Waldron, Indiana.

See, in this connection, a description of the section at the Tunnel Mill, south of Vernon, in Jennings County.

M. BIG CREEK, FROM DUPONT EASTWARD.

73. A short distance south of Dupont the railroad crosses Big Creek. Half a mile up the stream the clay of the Waldron shale horizon is quite fossiliferous, and contains the following species:

Duncanella borealis, Streptelasma radicans, Cyathophyllum calyculum, Striatopora gorbyi, Favosites spinigerus, Callopora elegantula, Fenestella sp., Lecanocrinus pusillus, Eucalyptocrinus crassus, Orthis (Rhipidomella) hybrida, Orthis (Dalmanella) elegantula, Orthotetes subplana, Plectambonites sp., Leptaena rhomboidalis, Spirifer crispus, Spirifer niagarensis, Whitfieldella nitida, Camarotœchia negleeta, C. acinus, C. whitii, Anastrophia internascens, Atrypa reticularis, Platyostoma niagarense, Cornulites proprius.

Farther up the creek, about two miles east of Dupont, is the Reuben Walker bridge. The Cliff rock here is at least 36 feet thick, and has been worked for bridge foundations. It is a first-class quality of rock, comparable with the Laurel limestone in the more northeastern counties. The Waldron clay overhanging the Cliff rock is 14 feet thick east of the bridge. Farther up stream, the base of the Cliff rock is found nearly eight feet below the Osgood limestone. On ascending the stream, all three formations are frequently exposed.

74. The localities which have furnished most of the cystideans collected by Mr. J. F. Hammell begin about three miles west of Bryantsburg and extend up Big Creek for two or three miles. Along this stretch the cystidean beds are frequently exposed.

75. About two miles west of Bryantsburg, on the north side of the stream, the following very typical section was found. Mr. Hammell supplied the data as to the cystidean beds.

Several feet of clayey shale, overlaid by two feet of more indurated clay rock, being the upper part of the lower Osgood clay. Greenish clay shale, a few inches, with few but very fine cystideans; hard, greenish clay shale, eight inches thick, the main cystidean bed; eight inches of greenish clay shale, rarely with cystideans. Twenty-one inches of irregular limestone layers, with *Holocystites wykoffi, H. spangleri.* Twelve inches of clay shale, with limestone nodules, containing *Stephanocrinus, Eucalyptocrinus* and *Caryocrinus hammelli;* in places it is full of fossils, and in others it is barren. Eighteen inches of a very hard crinoidal limestone, with *Holocystites ornatus* on its surface next succeeds, and above this is clay. A limestone layer, one and one-half inches thick, is sometimes found seven inches above the hard limestone; it contains *Holocystites ornatus.* The cystideans continue to be found in the clay beds for about 20 inches above the thin limestone; *Holocystites gyrinus* is found here. The space between this and the base of the Cliff rock is about five feet. It is the Upper Osgood clay horizon, but contains thin limestone layers at various horizons.

The cystidean beds include, therefore, the upper part of the Lower Osgood clay, the Osgood limestone and the lower part of the Upper Osgood clay.

76. This is the most northern point along Big Creek, according to Mr. J. F. Hammell, where the cystidean beds are exposed. If so, they recur again in the bed of Big Creek farther northward in Jefferson County.

Ripley County.

N. Big Creek and West Fork of Indian-Kentuck.

77. In Ripley County, a mile and a half north of the county line, Big Creek is crossed by an iron bridge, on the road to New Marion. The Osgood limestone here contains *Dalmanites limulurus*, *Plectambonites transversalis*, *Leptaena* (*Strophomena*) *rhomboidalis*, *Orthis flobellites*, *Orthis elegantula*, *Orthis*, related to *O. daytonensis*, *Atrypa reticularis*, *Spirifer radiatus*, *Caryocrinus ornatus* and *Pisocrinus gemmiformis*.

78. Half a mile northward, on the land of Orvin Campbell, the same limestone contains also *Calymene nasuta*.

79. A mile north of the county line, the west fork of Indian-kentuck is crossed by a road. The Osgood limestone contains *Pisocrinus gemmiformis*. The Lower Osgood clay is well exposed down stream. The Upper Osgood clay, with the lower part of the Cliff rock, are seen on ascending the hill.

O. East Fork of Indian-Kentuck.

80. Directly east of Haney's Corner the Clinton is 48 inches thick. Its color is salmon brown. The Osgood series is also exposed. The Clinton is again seen half a mile eastward, just before reaching a church.

81. A mile north of Haney's Corner a branch of Indian-kentuck exposes the Clinton. It is 48 inches thick, is of a salmon-brown color and shows no pebbles. It contains many fossils.

Above the Clinton are 10 inches of a siliceous, reddish-brown rock—the basal Niagara. The Lower Osgood shaly clay is 11 feet thick. Nea its top a cystidean was found. The Osgood limestone is represented b 25 inches of limestone, eight inches of clay and 10 inches of limestone. The Upper Osgood clay is 10 feet thick. The Cliff rock is exposed at the cross-roads northward.

82. About a mile northeast of Barbersville the Clinton is 36 inches thick and of salmon-brown color.

83. A mile farther north the salmon-brown Clinton is 30 inches thick.

84. Half a mile farther north and one and one-half miles directly

east of Haney's Corner is the farm house of Mr. Means. The Clinton is exposed in the run in the field northwest of the house. It is salmon brown in color, is 21 inches thick and contains *Illaenus ambiguus, Proetus determinatus, Orthis elegantula, Plectambonites transversalis* var. *sericea, Leptaena (Strophomena) rhomboidalis, Strophomena hanoverensis, Strophomena tenuis,* Clinton precursor, *Phaenopora fimbriata, Rhinopora verrucosa, Aspidopora parmula.*

Four feet below the Clinton *Tetradium minor* is found, accompanied by *Orthis biforata* and *Streptelasma corniculum.* Immediately below is a dark brown rock with fucoidal markings, similar to the layer in the Saluda Creek exposures. Three feet lower is the bluish layer with *Murchisonia hammelli* and *Orthoceras.*

85. A mile north of Haney's Corner, and then a little over a mile eastward, the road crosses a stream. Here the Clinton seems to be siliceous and of a reddish brown color. It is five to six inches thick. Some distance above is limestone with *Pisocrinus gemmiformis,* the Osgood limestone.

86. A mile northeastward, where the east and west road crosses the creek, and is joined by the creek road, there is an exposure. It is a little over a mile west southwest of the southern end of Benham's Corner. The Clinton is here 54 inches thick. Its color is salmon brown. No pebbles were seen.

Above the Clinton are nine inches of the siliceous reddish brown rock, identified as Clinton in some of the more eastern and southeastern sections. Above this are 16½ feet of the Lower Osgood clay shale, 12 inches of limestone with *Pisocrinus gemmiformis, Caryocrinus ornatus, a Whitfieldella* related to *W. cylindrica, Orthis elegantula, Atrypa reticularis,* and *Duncanella borealis.* Above are four to six inches of clay and 12 inches of limestone, the two limestones representing the Osgood limestone. The fossils occur in the limestone and the clay immediately above.

Below the Clinton are Lower Silurian fossils. *Tetradium* is common five feet below the Clinton.

87. A mile south of the cemetery, near the southern end of Benham's Corner, along a creek road, the Clinton is 25 inches thick, and of a salmon brown color. It continues to be exposed for half a mile up the creek, and is richly fossiliferous. Only *Illœnus daytonensis* and *Triplesia ortoni* were recorded. Pebbles are very rare. Five feet below the Clinton, *Tetradium* is common.

Northward, where the road leaves the creek, the Osgood beds are exposed. Just south of Benham's Corner the Cliff rock occurs.

88. A mile down the creek, following the road, a road turns off directly southward. In a direct line the locality is about three-fourths of a mile southwest from the last. The Clinton is here at least 16 inches thick and has a salmon-brown color. A few white pebbles occur.

89. About a mile east of the last locality, just before reaching a school house, the Clinton is exposed along the roadside. The exposure may be reached by going from Cross Plains one mile northward and a little over a mile westward. The Clinton here varies from six to nine inches in thickness. The upper portion at one point is crinoidal, and has a salmon-brown color. The middle and lower portion, and usually all of this thin layer of Clinton, is conglomeritic. Some of the white pebbles are three inches long, but most of the pebbles are small, about the size of fine gravel. Even in this conglomeritic portion there are, here and there, crinoidal remains of salmon-brown color. The lower part of the conglomeritic layer at times has a black color, and then is unlike anything ever seen in the western Clinton. In various parts of the Clinton conglomerate layer the much rolled fragments of Lower Silurian fossils may be distinguished. *Orthis occidentalis* is the most common species. In the clay beneath the Clinton Lower Silurian fossils are abundant.

P. TRIBUTARIES OF WILSON'S FORK. CROSS PLAINS.

90. Two miles west of Cross Plains, at a spring in the roadside, the Clinton is 13 inches thick, and has a salmon-brown color. It contains small white pebbles, similar to those at Osgood, but smaller, varying from one-quarter to one-half inch in size. It contains *Illaenus daytonensis* and *Orthoceras ignotum*.

91. At the north end of Cross Plains Village a siliceous, light reddish brown rock is seen. Its thickness is about nine inches. It is overlaid by whitish rock, followed by shale—the Lower Osgood shale.

92. A mile north from Cross Plains, and then a mile west on the crossroad, an exposure is found in the bed of a stream. The Clinton is a silicious, reddish brown rock. The Lower Osgood clay shale occurs above. The Cincinnati group occurs below.

93. Half a mile northward, on the east and west road, occurs another exposure. From the cemetery at Benham's Corner the road leads east one sixth of a mile, south three-quarters of a mile, after one eastward turn in the road, south one-quarter of a mile, then east three-quarters of a mile. The Clinton is exposed in a little stream bed north of the road. It is siliceous, reddish brown in color, and nine inches thick. The blue Cincinnati rocks occur below.

Q. OLEAN TO VERSAILLES.

94. Going from the cemetery at Benham's Corner one mile north, and then a short distance east, the road crosses a small stream. North of the road the stream gives a fine exposure of the salmon-brown Clinton, 36 inches thick. Lenses of white rock occur in the Clinton, but no real pebbles were noticeable

95. Half a mile northwest of Olean, on the road leaving the north end of the village, the salmon-brown Clinton is 24 inches thick.

The Clinton is again exposed before reaching the northern line of Brown Township.

96. Northwest of Olean the Clinton is exposed at several points where streams cross the road. A little over half a mile northward there is a stream which exposes the Clinton at a small fall west of the road. It has a salmon-brown color, is 50 inches thick, and is full of fossils. East of the road there are two falls in the Madison beds. The lowest and highest of these is known as Cooper's Falls. The upper strata are here 29 feet below the base of the Clinton, and 28 feet above the base of the falls, giving a total section of 57 feet to the Madison beds. These Madison beds, however, resemble the sections given by the falls near Laurel more than those at Madison, in that there is a considerable quantity of clayey shale in the section.

97. Three-fourths of a mile northward the Clinton is exposed at the top of Curran's Falls, east of the road and a short distance north of the junction of two roads. The Clinton is of a salmon-brown color, is 46 inches thick, and near the bottom contains plenty of white pebbles, similar to those found at Osgood. The pebbles are usually one-fourth of an inch in length, but some two inches long are found. The pebbles sometimes show the presence of worm burrows, filled with the salmon-brown Clinton material. These pebbles may have been formed from a Lower Silurian stratum, such as is frequently found immediately beneath the Clinton.

98. A mile and three-quarters northwards, the Clinton east of the road is 64 inches thick. It contains lenses of white rock.

99. The first Clinton outcrop along the road, going south from Versailles, occurs one-third of a mile north of the locality just mentioned. Clinton bowlders, derived from the field, are found, however, at various points farther northward.

100. In the southwestern part of Versailles, on the road to Tanglewood, west of a saw-mill, so many Clinton bowlders have been picked up in the fields that the line of Clinton outcrop can be well followed. The Clinton here contains many white pebbles.

R. VERSAILLES TO OSGOOD.

101. *Versailles*—about five miles south of Osgood. About two miles south of Osgood the old road to Versailles leaves the pike and takes a straighter but more hilly course for Versailles. About a mile farther on, Cedar Creek comes within 50 feet of the road. Poor wave marks occur in one layer of limestone in the bed of the creek, the ridges running N. 80 W. The rock along both sides of the bank is Lower Silurian. The highest exposures on the hillside and along the small branch entering

Cedar Creek from the west, are still Lower Silurian, although some of these Lower Silurian limestones are very white and lithologically resemble some of the Niagara limestones found elsewhere. Lower Silurian fossils, however, overlie these white limestones and exclude the idea of the presence of Niagara rocks in this vicinity.

101 *a*. About two miles southward, the old road to Versailles passes down a steep incline into the deep valley of a branch entering Cedar Creek from the west. About opposite to the beginning of this steep descent of the road the bed of Cedar Creek, over a hundred feet down, shows limestone beds with well defined wave marks, the ridges running N. 18 W., the crests being 23 to 25 inches apart and from one to one and one-third inches above the deepest part of the depression between the ridges. Lower Silurian fossils are very common at this low level, *Tentaculites* (species unknown), *Orthis* (*Dalmanella*) *testudinaria* and *Strophomena filitexta* being common. Lower Silurian fossils occur up to the very summit of the hills bordering the valley.

Ascending the hill on the side of the valley formed by the branch of Cedar Creek already mentioned, the rather steep road enters Versailles from the north. A very detailed section of the upper portion of the exposures along this road was prepared and will serve to show some of the main lithological features of the upper Lower Silurian at this point. The section is given in descending order, going from the north end of Main Street, in Versailles, northwards down the road.

In the clay overlying the limestones, at the very top of the section, are found *Orthis* (*Platystrophia*) *biforata*, *Orthis* (*Herbertella*) *occidentalis*, *Strophomena sulcata* and *Callopora* (*Monticulipora*) *ramosa*, showing that no Upper Silurian rocks occur at this point. Beneath the clay occur: five inches of limestone, siliceous, with concretionary bodies of small size, and containing at one place a specimen of *Byssonychia* (*Ambonychia*) *radiata*; 10 inches of limestone, with fossil shells replaced in part by crystalline calcite; 11 inches of solid bluish limestone, apparently with *Isochilina*; 15 inches of irregularly seamed limestone, bluish and brownish, with an interior cast of *Byssonychia* (*Ambonychia*) *radiata*; 19 inches of more solid blue limestone; 41 inches of a bluish, more clayey rock, weathering along minute cracks to a brownish color, giving the rock a sort of reddish effect at a distance. This rock at times has a purplish-brown hue, and apparently contains *Isochilina subnodosa*; beneath it are eight inches of solid blue limestone; 15 inches of fragments of rock with *Isochilina subnodosa*; 15 inches of solid blue limestone with *Tetradium minor* on the upper surface. Towards the east, along the creek side, this layer shows fine vertical borings, possibly made by annelids; beneath this layer, on the creek side, are eight inches of clay; four inches of limestone; four inches of limestone; six inches of limestone; 10 inches not exposed; 48 inches of a rubbly-brown, clayey rock, like the much cracked *Isochilina* layer men-

tioned above; five feet not exposed. Then, along the roadside again, 11 inches of a more solid rock layer, full of fossils, especially along the upper surface, such as *Byssonychia (Ambonychia) radiata*, and the thicker species of *bryozoa;* seven inches of solid blue limestone, with *bryozoa* well shown along the upper surface; six inches not exposed; nine inches of solid blue limestone, with numerous vertical holes; four inches of thin limestone layers; 16 inches of very solid blue limestone. Next come 106 inches of brownish and bluish, thin, practically unfossiliferous shales, with good shaly partings; 10 inches of solid blue limestone; eight inches of shale; seven inches of blue limestone; five inches of shale. Next come 17 inches of limestone with *Byssonychia (Ambonychia) radiata* and *Tetradium minor;* beneath it, separated by a clayey parting, come 16 inches of blue limestone with *Orthis (Platystrophia) biforata* and *Tetradium minor;* 45 inches of a rubbly-blue limestone, with frequent specimens of *Tetradium;* 33 inches of similar stone with *Tetradium;* 15 inches of solid rock, composed almost altogether of *Tetradium*. Then occur 16 inches of bluish clay with *Favistella stellata*, followed by 12 inches more of clay; four inches of limestone, with frequent specimens of *Orthis (Platystrophia) biforata*, and *Orthis (Herbertella) sinuata*, of very characteristic form, and quite common; 76 inches of shaly rock, containing several thin limestone courses; eight inches of limestone in two layers, with numerous fossils, among these *Strophomena (Rafinesquina) alternata;* 18 inches of clayey rock; four inches of solid limestone; 15 inches of thinner limestone courses; eight inches of limestone; five inches of limestone. Then, going down the hill, there are about 30 feet of rocks not well exposed along the road. Beneath this occur 40 feet of very fossiliferous strata, containing an abundance of all sorts of fossils, down to the level of the creek. Among these fossils are: *Orthis (Herbertella) sinuata, Strophomena filitexta, Strophomena (Rafinesquina) alternata, Leptæna (Strophomena) tenuistriata, Rhynchotrema (Rhynchonella) capax, Pterinea demissa*, and *Streptelasma corniculum*.

In condensed form the section may be said to consist of five feet of limestone, five and a half feet of the *Isochilina* bearing clayey rock, a *Tetradium* layer, one foot thick; two and two-thirds feet of limestone rock; four feet of the clayey rock, similar to that containing *Isochilina* higher up; nine feet of limestone layers, a total so far of 27 feet, chiefly of limestone. Beneath this are found nine feet of unfossiliferous brownish and bluish shales, two and a half feet of limestone and shale, 12½ feet of layers containing *Tetradium*, with a layer containing *Favistella* beneath, a total distance of 52 feet beneath the top of the section. Next beneath are 10 feet of chiefly clayey material, often with shaly partings, three feet of limestone, thirty feet of unknown character and about 40 feet of very fossiliferous limestones and clayey shales to the bed of the creek, a total of 125 feet to the section.

A third way of describing the section would be, a thickness of 85 feet of rock and shale but moderately supplied with fossils, underlaid by 40 feet of fossiliferous limestones and shales.

In this form the section can be used to determine the relative position in the Lower Silurian of various exposures along Laughery Creek and its branches in Ripley County. The Clinton is exposed on the southwestern side of Versailles. The Niagara is not present in the immediate vicinity of Versailles, although found farther westward. It is not probable that the Niagara occurs anywhere towards the east of Versailles, the line of outcrop passing from Osgood toward the west of Versailles.

102. About half a mile east of Osgood, on an east and west road, at least four inches of Clinton rock are exposed. It is of salmon-brown color and contains many white pebbles. Some of the pebbles are three inches long. Beneath the Clinton is a four-inch layer of white limestone with Lower Silurian fossils, which has furnished the material for the pebbles.

103. About a mile and a half south of Osgood, at the end of a short branch of the railroad, is Nick Wagner's quarry. The Laurel formation is here well exposed, and the following thicknesses of limestone are secured, the ledges being followed from the bottom upward: 6, 16, 8, 3, 10, 7, 4, 5½, 3, 5, 5, 7, 5, 5 inches. From the eastern side of the quarry a creek flows eastward. This exposes, several hundred yards away, a ledge of limestone on a level with the base of the quarry, with *Pisocrinus gemmiformis*. Shaly rock seems to underlie it.

104. A mile southwest of Osgood, on the northern side of the railroad track, is Al. Ashman's quarry.

Beginning with the bottom, the Laurel limestone presents the following layers: 16, 9, 3½, 8, 9, 5, 11, 11, 8, 6, 10, 14, 8, 11 and 4 inches.

105. In the northeastern part of Osgood, along the road south of the railroad track, the Clinton is 28 inches thick. It has a salmon-brown color and at its base includes pebbles of a whitish Lower Silurian limestone. The fossils are *Illaenus daytonensis, Illaenus ambiguus, Plectambonites transversalis* var. *elegantula, Orthis calligramma, Rhinopora verrucosa, Heliolites subtubulatus.*

Above the Clinton is the Lower Osgood clay horizon, about 76 inches thick. Then come in several limestone beds with *Atrypa reticularis.*

106. At the north end of Osgood are some quarries exposing the Osgood limestone, about 30 inches thick. The Clinton is found eastward in the bed of a stream in a field, eight feet below the Osgood limestone. The partings between the Osgood limestone layers contain many fossils.

S. OSGOOD TO NAPOLEON AND VICINITY.

107. From Osgood two miles northward on the Napoleon pike, and thence eastward one mile, there is an exposure of the Clinton in the bed of a stream north of the road. The Clinton is here quarried for road material. It is of salmon-brown color, is 34 inches thick, and at its very base contains pebbles and brecciated fragments of white rock. Lenses of white rock occur at various levels in the Clinton.

The layer of Cincinnati limestone just beneath the Clinton is very white and fine-grained, and probably furnished a part of the pebble material at the base of the Clinton.

The fossils in the Clinton are: *Illænus daytonensis*, *Illænus madisonianus*, *Plectambonites transversalis* var. *elegantula*, *Leptæna* (*Strophomena*) *rhomboidalis*, *Strophomena hanoverensis*, *Strophomena patenta*, *Strephomena tenuis*, *Orthis calligramena* var. *euorthis*, *Orthis* (*Platystrophia*) *biforata*, *Orthis* (*Dalmanella*) *elegantula*, *Clathropora frondosa*, *Phœnopora fimbriata*, *Pachydictya bifurcata*, *Pachydictya turgida*, *Rhinopora verrucosa*; *Heliolites subtubulatus*, *Favosites favosus*, large tubes, *Halysites catenulatus*, *Cyathophyllum caliculum*.

108. The Clinton is exposed a quarter of a mile farther east, on the roadside east of a cemetery. Twenty-six inches are here seen, but the exposure is not a good one.

109. A mile eastward, and then a mile northward, the northern end of a long hill is reached. Going down into the valley northward, solid layers of Lower Silurian limestone are found 53 feet below the summit of the hill land. The limestone is two and one half feet thick, and is underlaid by eight and one-half feet of shaly stone similar to that found in the section immediately north of Versailles. At Versailles the shale layer is about nine feet thick and is found about 28 feet below the top of the exposed section. The Clinton occurs at Versailles not far above the top of the section as exposed north of town. Judging from this the level of the Clinton should occur considerably below the hill top at section 109, here described. The Lower Silurian limestone farther down the hill, and also half a mile westward, where a stream crosses the east-west road, contains concretions enclosing fossil remains.

110. A mile and a half northwest of the last locality, on the road to Napoleon, the salmon brown Clinton is 14 inches thick. It contains *Orthoceras virgulatum* (?) and *Phœnopora fimbriata*. The Lower Silurian limestone immediately beneath is white in color, and is penetrated from above by worm burrows which are filled by salmon-brown Clinton material. The burrows were evidently made in Clinton times. A short distance westward, southeast of a road corner, the Laurel limestone, or Cliff rock, is quarried by Jos. Remstedt.

111. From this road corner, half a mile westward and then half a mile northward, the Osgood limestone with *Pisocrinus gemmiformis* is exposed on the east side of the road at a creek crossing. A little over half a mile northward the Clinton is exposed just south of a road corner. The Clinton is exposed several times a quarter of a mile farther north. Beneath the Clinton at this locality there is a four-inch layer of white Lower Silurian limestone, with over three feet of clayey material, full of loose fossils. The locality number refers to this exposure.

112. A third of a mile northward is an excellent exposure of the Clinton on the east side of the road in a stream bed. Its thickness is five feet. Its color is salmon brown. It contains lenses and, in places, even layers of white rock. This rock, in places, contains worm burrows filled with the salmon brown material from the layers immediately above. The fossils are *Strophomena hanoverensis*, *Orthis calligramma* var. *dinorthis*, *Clathropora frondosa*, *Rhinopora verrucosa*, *Heliolites subtubulatus* and *Favosites niagarensis*.

113. The Clinton is exposed along a stream bed a third of a mile northward, north of the crossroads, and also a quarter of a mile and again half a mile east of this road corner.

114. At Napoleon the stream bed exposes the white Laurel limestone. North of the town, a fifth of a mile east of the Napoleon-Greensburg road, the Osgood limestone is exposed in the stream bed. Along the same stream, nearly three-quarters of a mile north of Napoleon, the salmon-brown Clinton is exposed on the west bank. It is 14 inches thick and overlies a hard, whitish or grayish, shaly parted limestone. A fifth of a mile northward the east bank of the stream exposes Lower Silurian rock, richly fossiliferous.

115. A quarter of a mile southward, on the west side of the stream, north of the roadbed there is an exposure of salmon-brown Clinton two feet thick. It is not exposed in the roadbed, nor on its southern side. The place of the Clinton seems to be occupied by a hard, whitish, shaly parted limestone. The exact relation of this rock to the Clinton is not known, the intermediate region being not sufficiently exposed. But it is not impossible that the Clinton turns within a few feet to a fine-grained, whitish limestone. Above the Clinton lie three or four inches of clayey white limestone, then 12–15 inches of Madison-like, brownish limestone. The Osgood limestone occurs several feet higher up, westward, in the roadside. Below the Clinton are thin courses of brownish and bluish shaly and clayey limestone, without fossils, excepting worm burrows.

116. A third of a mile westward, and then a quarter of a mile northward, just north of a road corner, a small branch crosses the road at the house of David L. Eaton. The base of the Cliff or Laurel limestone is exposed along the road, and also above the stream east of the road. Only

two and one-half feet are exposed. Beneath this are three inches of shale, six inches of clayey limestone, nine inches of shale, four inches of limestone, and then a little over four feet of shale. This shale does not seem to occur in the sections near Osgood. It replaces in part the base of the Laurel bed. Below this shale is found the top layer of the Osgood limestone. It is 11 inches thick, and contains *Pisocrinus gemmiformis*, *Illaenus insignis*, and other fossils. Beneath this layer are found two feet of softer, irregular bedded limestone, which weather back, and evidently correspond to the rubbly limestone of the sections near Osgood. Beneath this, but west of the road, down the stream, are found 12–15 inches of the Madison-like, brownish, clayey rock. Below this are two to three inches of the whitish basal Niagara limestone with crinoid beads. The Clinton, immediately beneath, thickens within a short distance, on going eastward down the stream, from 15 to fully 30 inches. Its color is salmon brown. The top of the Lower Silurian is formed by a white limestone layer.

T. MOST NORTHERN EXPOSURES ON LAUGHERY CREEK AND ITS DECATUR COUNTY BRANCHES.

117. The Rolfing and Wagner school house locality was visited on a former occasion. The Clinton is about one foot thick, and has a salmon-brown color. Above the Clinton were two feet of whitish limestone, apparently the Osgood limestone. The shaly layers immediately above correspond to the shaly layers as seen at the last described locality. See in this connection the New Point section, where this shale does not occur, and where the section can be better compared with the Osgood section.

118. A mile eastward, the Clinton is exposed along the road side, south of the bridge leading across Laughery Creek. It is salmon brown in color. Its total thickness is unknown.

119. The Clinton is exposed again nearly two miles northward, nearly half a mile south of New Pennington, in a small stream bed. The Lower Silurian is crossed by the road bed.

120. A mile east of New Pennington a stream exposes, along its banks, the fossiliferous Lower Silurian.

121. A road leads southward on the western side of the stream. A mile and a half southward along this road the salmon-brown Clinton is exposed west of the road, along the high banks of the stream. It occurs again at various points farther southward. None of these exposures have any considerable thickness, but the total thickness of the Clinton is probably not exposed.

U. NEW POINT.

New Point Quarry.—A mile north of New Point, east of the road, along a branch of Salt Creek, at the east end of the Big Four quarries, a quarter of a mile west of Rossville. Along the creek the salmon-brown Clinton is 33 inches thick. It contains *Clathropora frondosa* and numerous other fossils. Below the Clinton is a white layer of Lower Silurian limestone, underlaid by softer blue limestones and clayey shales.

Over the Clinton lie 44 inches of a clayey limestone; above this lie 18 inches of rubble limestone with clayey partings; the limestone is fossiliferous, and weathers back. Above this are two feet of rubble limestone, weathering less easily, and containing numerous fossils. Above this lies a 12-inch layer of solid limestone, the Osgood limestone. Immediately above begins the Cliff bed or Laurel limestone. This part of the section corresponds closely to the section at 104, at the quarry a little over a mile southwest of Osgood, and also to the lower part of the section at 116, David L. Eaton's, two miles south of Napoleon. The railroad company quarries the inferior clayey rock just above the Clinton, under the name of a soap-stone, the lower layer being eight inches thick, the upper 26 inches. The inferior rubble limestone comes out in ascending order in 15, 12–15, 24 and 12–24-inch layers, according to the quarrymen. This rock consists essentially of irregular limestone patches in a soft, clayey rock which will not withstand weathering. Over this is an 18–20 inch layer of a clayey rock which will not withstand weathering, which is called the soap stone ledge. Over this, according to the quarrymen, lie the following layers of white limestone: 8, 36, 18, 9, 12, 9, 14, 10, 8, 7, 6, 4, 3 inches. These upper layers are composed of an excellent quality of white limestone. The lower eight-inch layer may possibly represent the Osgood limestone of the creek section. The upper layers are the Cliff or Laurel limestone. The lower, Osgood, beds should not be used for purposes where weathering may endanger the rock. The softness of the same layers 200 feet away, along the creek, shows their inferior character when exposed to weathering. Sometimes the upper two to four inches of Clinton are so firmly united to the base of the Niagara, as to be quarried up with the latter.

V. BIG GRAHAM CREEK AND LITTLE OTTER CREEK.

122. The most eastern exposure of the Clinton along Big Graham occurs a little over a mile south of Versailles, on the road to Titusville. Its thickness could not be determined; its color was salmon brown.

123. The next exposure is a mile and a half southwest of Versailles, on the road to Tanglewood church, where a small stream crosses the road.

It is near the Adam Caplinger house. The Clinton is 28 inches thick, has a salmon-brown color, and contains, near the base, pebbles of white rock.

Above the Clinton are six to eight feet of greenish-brown shales, the equivalent of the Osgood clay.

The Clinton contains the following fossils: *Illœnus ambiguus*, *Proetus determinatus*, *Plectambonites transversalis* var. *elegantula*, *Leptœna* (*Strophomena*) *rhomboidalis*, *Strophomena hanoverensis*, *Strophomena tenuis*, Clinton precursor, *Orthis calligramma* var. *euorthis*, *Orthis elegantula* var. *parva*, *Atrypa latacorrugata*, *Clathropora frondosa*, *Heliolites subtubulatus*.

About four or five feet beneath the Clinton base, fragments of Lower Silurian rocks were dug out of the bottom of the stream bed, and contained in the bluer layers: *Orthis* (*Platystrophia*) *biforata*, *Orthis* (*Herbertella*) *occidentalis* and *Protarea vetusta*. In the white limestones, associated with the bluer layers, are frequent specimens of *Tetradium*, frequently penetrated by the limestone cement along vertical cavities, probably caused by boring animals.

124. Three-quarters of a mile westward and half a mile southward is Tanglewood church. A stream crossing the road shows the Clinton, quite a distance east of the road. The Clinton is of salmon-brown color and contains white pebbles.

Above the Clinton are eight feet of clayey shale, the Lower Osgood clay. Then 32 inches of limestone in several courses, some of them separated by thin clay layers. The lower layer of limestone contains a *Whitfieldella* related to *Wh. cylindrica*. Above the Osgood limestone, west of the road, there is no exposure for about four feet; this, with the lower portion of the next higher exposures, gives a total thickness of about six to eight feet to the Upper Osgood clay. Above this lie 10 feet of white limestone, the Laurel bed. The upper layer of this limestone is coarse grained and contains *Dalmanites limulurus*. *Pisocrinus gemmiformis*, *Atrypa reticularis* and *Spirifer crispus* are found at various levels. The Laurel bed is worked under the name of Ead's quarry.

The Laurel bed is also exposed northward at John Jackson's quarry, a quarter of a mile west of the Adam Caplinger exposure.

125. Nearly two miles southward, where the creek road crosses over to the north side of the creek, going west, a small stream enters from the south. The Clinton in this stream is only four inches thick, and is full of white pebbles. The Lower Silurian beneath the Clinton is a mass of whitish rock fragments and clay, at least five feet thick.

126. A mile westward, on a road leading northward from the creek road, the salmon-brown Clinton is 15 inches thick, and includes white pebbles near its base. It contains *Orthis calligramma* var. *euorthis*, *Phœnopora fimbriata*, *Heliolites subtubulatus*, *Halysites catenulatus*.

Above the Clinton are at least six feet of soft, clayey shale, and then white limestone with a *Whitfieldella* related to *Wh. cylindrica.*

Immediately below the Clinton is white Lower Silurian limestone, with a species of *Lophospira* and *Orthis biforata.* In the creek bed are thick massive clayey limestones, with *Leperditia* and other remains, similar to the upper beds of Lower Silurian age, north of Versailles.

127. A little over half a mile westward, south of the Big Graham, where the road crosses to the southern side, at least 10 inches of salmon-brown Clinton, containing pebbles, are exposed.

128. A fourth of a mile westward, a partly abandoned road leaves the creek road and ascends the valley of a branch, northward. About a mile and a half north of the Big Graham this branch is joined by another stream. Along the road, near the junction, the Clinton boulders are often eight inches thick and contain pebbles. The color is salmon brown.

129. Half a mile southwest of the junction of the northern branch with the Big Graham, a small stream crosses the road east of William Muth's house, just before reaching the point where the creek road crosses over to the north side of the creek. The Clinton in the stream bed is four inches thick, has a salmon-brown color, and contains white pebbles.

The Lower Osgood clay shale and the Osgood limestone are well exposed.

The section along the creek road does not show any Clinton.

130. Nearly a mile southwest of this locality is the Michigan Road. Along the creek road, a hundred feet northeast of its junction with the Michigan Road, the Clinton is absent.

The base of the Niagara is represented by a four-inch layer of bluish-white limestone. The clayey shale and rubble stone above this represent the Osgood clay, and are about eight feet thick. Three layers of limestone with the interbedded clayey shale, measure three feet in thickness, and represent the Osgood limestone. Fossils are found in this stone, and in the clay immediately above.

Below the basal Niagara is a four-inch layer with *Labechia.* Below this layer Lower Silurian fossils are common.

In the Osgood beds, in the limestone layers and the associated clays, are found *Orthis calligramma* var. *euorthis, Whitfieldella,* a form related to *Wh. cylindrica, Atrypa reticularis and Spirifer radiatus.* Loose slabs of Osgood limestone contained in addition: *Dalmanites limulurus, Orthis (Dalmanella) elegantula, Plectambonites transversalis, Rhynchotreta cuneata* var. *americana, Pisocrinus gemmiformis, Stephanocrinus osgoodensis,* and *Caryocrinus sp.*

131. On the southern side of the Big Graham, a short distance south of the last exposure, and at the northern end of New Marion, the Clinton is also absent. The basal Niagara is eight inches thick. It is overlaid by 10½ feet of Lower Osgood clay, 34 inches of the Osgood lime-

stone, in several courses with clay partings, and six feet of the Upper Osgood clay. The lower part of the Cliff rock is seen farther up the road; at least 10 feet are exposed.

Below the basal Niagara are 20 inches of blue shaly clay, and then nine feet of clay with numerous Lower Silurian fossils. There are five feet of solid limestone, beneath which there are three feet of clayey limestone like the layers containing *Leperditia*, north of Versailles.

The Osgood limestone and the immediately overlying clays contain many Niagara fossils. Those from the clay can be easily secured. In addition to the fossils found north of the creek, there are here seen: *Leptæna rhomboidalis* and *Spirifer eudora*.

The Laurel limestone contains *Pisocrinus benedicti*.

132. The Clinton is also absent along the Big Graham, where crossed by the New Marion-Butlerville road, one-half mile west of New Marion. The basal Niagara limestone is 11 inches thick. The Lower Osgood clay is at least eight feet thick. The Osgood limestone and the Upper Osgood clay were not measured. The Cliff rock is at least 15 feet thick.

Below the basal Niagara are six inches of clay with *Streptelasma corniculum*, *Orthis occidentalis*, and *Callopora (Chaetetes) dalei*. The highest limestone layer of Lower Silurian age contains *Labechia*.

133. A mile and a third west of New Marion the Butlerville road is crossed by a small stream. West of its junction with the Big Graham the Clinton is exposed on the hillside. It is seven inches thick, has a salmon-brown color and contains plenty of white pebbles in the lower half.

Immediately beneath the Clinton is a white Lower Silurian limestone similar lithologically to that composing the pebbles.

134. A mile and a half southwestward, where Haines' branch crosses the east and west road, south of the Big Graham, the upper 18 inches of the Clinton do not contain pebbles. The lower four inches of the Clinton contain numerous, chiefly small, pebbles. The total thickness is 22 inches; the color is salmon brown.

The basal Niagara is siliceous and is nine inches thick. The upper layer of limestone of Lower Silurian age is of drab color and is four inches thick. Beneath are six feet of Lower Silurian rock.

135. A mile west of the Haines' branch exposure, where the road reaches the creek and soon after becomes indistinct, the salmon-brown Clinton is 10 inches thick. The lower six inches contain pebbles, some of them two inches long.

The basal Niagara is three inches thick. The Lower Osgood clay is nine feet thick. The Osgood cystidean limestone is 42 inches thick and contains *Illaenus ioxus* and other fossils.

136. No Clinton is exposed 200 feet west of the last locality. It is certainly absent in the stream bed, one-fourth of a mile southwestward.

137. Half a mile westward, west of the cemetery northeast of Benville, the stream exposures show one inch of Clinton of salmon-brown color, consisting chiefly of small pebbles, but also containing *Orthis calligramma* var. *euorthis* and *Strophomena patenta*. The basal Niagara is two and one-half inches thick. The bluish rock at the top of the Lower Silurian is four inches thick. It was cracked before the deposition of the Clinton material began, and salmon-brown Clinton material now fills up the cracks. At some points along the stream no Clinton can be found.

138. The northeastern exposure of the Lower Silurian along Little Otter Creek is two and one half miles northwest of New Marion, in a direct line, and two and one-fourth miles east of the county line. No Clinton is present. The white siliceous limestone, usually found above the Clinton in the western part of Ripley County is here two inches thick. The 15 inches of thin layers of white limestone beneath the two inch layer resemble thin Niagara flagging stones, but are believed to be of Lower Silurian age. Beneath this is a dark shale with fucoidal markings, resembling the dark shale with the fucoidal markings in the Saluda Creek exposures.

139. A mile southwestward, south of a school house, the road exposure does not show any Clinton, but a little westward, along the roadside, the Clinton was at least six inches thick and contained white pebbles. Its color is salmon brown.

140. A mile westward, where the creek is crossed by a road, one-fourth mile east of the county line, there is no Clinton. The basal Niagara limestone is white and siliceous, like that near Benville. The upper portion of the Silurian is bluish and contains many specimens of *Byssonychia radiata* and other more common fossils. The Osgood limestone contains *Pisocrinus gemmiformis*. The Lower Osgood clayey shale is well exposed on the northern side of the creek, west of the road crossing.

W. BIG OTTER CREEK AND BRUSH CREEK.

141. The Al. Ashman quarry, locality 104, is found a little over a mile southwest of Osgood, north of the railroad. There is an almost continuous exposure of the Laurel formation for nearly three-fourths of a mile westward to where the salmon-brown Clinton is exposed in the creek bed east of an old abandoned road, northeast of a farmhouse. The Clinton is at least six inches thick. The thin basal Niagara is not exposed. The clayey bed immediately above is 44 inches thick. This layer often resembles the Madison bed, which is, however, Lower Silurian. Above the clayey rock are 40 inches of clayey and rubbly limestone, followed by three inches of clay, and then by 11 inches of solid Osgood limestone. The Cliff or Laurel limestone can not be sharply distinguished from the

Osgood limestone, the Osgood bed forming the base of the almost continuous limestone section. I examined the clay layers immediately above and below the Osgood limestone for cystideans, but did not find any.

142. A mile west-northwest, east of a branch of the creek, along the road-side, the salmon brown Clinton is at least six inches thick. It contains a few small white pebbles. Beneath the Clinton lie eight inches of white Lower Silurian limestone; then Lower Silurian rock full of bryozoans. Above the Clinton, ten feet eight inches, is a 14-inch layer of Osgood limestone, with *Pisocrinus gemmiformis*. Below this thick bed are several thinner limestone layers, also with crinoidal remains.

143. A short distance westward and then three-fourths of a mile northward, the salmon brown Clinton is exposed where a small stream crosses the road. It is 15 inches thick, and contains a few white limestone pebbles three inches long. Six inches below the Clinton is a 12-inch layer of crystalline, white, glassy limestone, containing long cavities, in some cases evidently locating the former presence of branching bryozoans, their structure being still retained around the margins of the cavities.

144. The Lower Silurian limestone, nearly two miles down the creek, south of a road crossing, contains concretions around small fossil remains.

144a. From locality 142, a short distance westward, and then half a mile north on the Michigan Road, to a stream; the salmon-brown Clinton is at least eight inches thick; total thickness not known. It is cross-bedded. Below it is Lower Silurian limestone, eight inches thick, containing large oölitic concretions.

144b. A short distance northeast, at another road crossing, the banks of the stream expose Osgood limestone.

144c. Half a mile northward, on the east side of the stream, the bank exposes 15 inches of Osgood limestone, over three inches of clay, and three feet of rubbly limestone.

145. A mile and a quarter north of Osgood, and then a mile and a half westward, the road crosses a stream emptying into the northern branch of Big Otter Creek. South of the road the upper layer of Osgood limestone is 14 inches thick; it is underlaid by three inches of clay, and then by 19 inches of limestone in thin courses, the whole representing the Osgood limestone. Below are found 20 inches of thin rubble limestone with clay partings. Then 39 inches of Madison-like, light brown, clayey rock, fairly solid, but becoming soft under the influences of weathering.

146. Farther down the stream, west of the Michigan road, the salmon-brown Clinton is exposed. A considerable distance west of the road the Clinton is well exposed, and is 24–27 inches thick. It contains *Clathropora frondosa* and *Heliolites subtubulatus*.. The Clinton rests upon

white Lower Silurian limestone. This is penetrated by worm burrows filled with salmon-brown Clinton material. Farther down stream the Lower Silurian limestone below the Clinton is four to eight inches thick, contains numerous concretions, and also bryozoans and gasteropods. The upper surface of the Lower Silurian is a little uneven, the base of the Clinton being let down into the depressions of the Lower Silurian.

147. A mile directly westward, where the two main forks of the northern branch of Big Otter Creek meet, there are three feet of salmon-brown Clinton limestone exposed.

148. Half a mile southward the Clinton is better exposed. It is salmon brown in color and 50 inches thick. Above it are 40 inches of the Madison like clayey rock, 40 inches of rubble limestone and a 15 inch layer of Osgood limestone, with a thin clay layer between this and the rubble limestone beneath.

Below the Clinton are two inches of white Lower Silurian limestone, three feet of clayey material with bryozoans and fragments of thin limestone, a 12 inch layer of limestone with bryozoans, eight inches of clay, three feet of more solid limestone with *Tetradium*, then three feet of fossiliferous limestones alternating with clay, finally four feet of solid limestone full of fossils and containing numerous limestone concretions.

149. Half a mile down the creek, west of the road where it crosses over to the western side of the creek, the salmon brown Clinton is 15 to 18 inches thick. It contains very few pebbles. Ten and one-half feet above the Clinton the Osgood limestone is 12 inches thick; the rubbly limestone occurs below.

150. Half a mile southward the steep banks east of the creek, 15 feet above the creek, show an 18 inch bed of Lower Silurian limestone full of *Tetradium;* three feet higher up, loose blocks of *Labechia* are found.

151. Half a mile southward, northwest of a school house, at the road corners west of the creek, the top of Lower Silurian section contains concretions in the limestone layers. Above this are specimens of *Labechia* and then 25 feet above the creek is found the salmon-brown Clinton. Only eight to 12 inches are exposed, and this is evidently not the total thickness. It contains lenses and even thin intercalated layers of whitish limestone. A hundred feet north of the school house the Clinton contains white, fine grained limestone pebbles of Lower Silurian origin.

152. About two miles down the creek, along the road going west from the creek, the Clinton is absent, but a pebble of Clinton rock, three inches long, nearly as broad, and one-half inch thick, was found within two inches of the base of the white basal Niagara limestone. Its color was salmon brown, mixed with blackish. Immediately beneath was clay with *Tetradium*, then Lower Silurian fossils, and farther down was Lower Silurian limestone with small concretions. The base of the Niagara was 40 feet above the creek.

153. East of the creek, along the same road, the Niagara is underlaid by clay and then the *Tetradium* layer. The Clinton is absent. Some distance down is Lower Silurian limestone with concretions, and still farther down is limestone with ostracod remains, among others a species with a vertical groove, near the middle of each valve, extending a short distance downward from the hinge.

154. A mile southwestward down the creek, northward along the road leading up from the creek, worm burrows of a very peculiar character are found in the Lower Silurian. They resemble, crudely, specimens of *Orthoceras*, with partitions, but without a siphuncle.

155. South of the road, along the western bank of the creek, the Lower Silurian limestone contains concretions. A little higher up is found the basal Niagara limestone, overlying a thin blue clay layer, with branching bryozoans of Lower Silurian age.

156. Three-fourths of a mile southwestward down the creek, on the western side of the creek, large *Tetradium* masses are found. They belong to the variety which seems to be massive below, but which occasionally branches above. Immediately above is the white basal Niagara limestone, 15 inches thick, formed of thin courses. The Clinton is absent. Below the *Tetradium* layer is Lower Silurian limestone with large oölitic concretions, fragments of *Orthis occidentalis* and *Callopora dalei*.

157. A mile and a half southwestward down the creek, a short distance north of the railroad crossing, in a short gully, the top of the Lower Silurian limestone is found 24 feet above the base of the creek. It contains concretions, enclosing fragments of *Orthis*. Clay, one to two inches thick, intervenes between this and the basal Niagara limestone. The latter is white and 12 to 15 inches thick. The region of the Madison-like clayey rock, five feet thick, is not exposed. Rubble limestone and clay, seven feet thick, overlie this horizon; the rubble limestone contains good fossil remains, *Spirifer niagarensis*, *Atrypa reticularis*, *Favistella*. Above this is a 12 to 15 inch layer of solid Osgood limestone.

X. MUSCATATUCK CREEK AND ITS DECATUR COUNTY BRANCH.

158. About two miles a little north of west from locality 152, south of the road, along the eastern side of a stream, there is a fairly high bank exposing the upper part—three feet—of the Madison-like, bluish and light brown clay rock which belongs at the base of the Niagara section. Above this are six feet of rubble limestone with intercalated clay beds. Then one foot of solid limestone, the Osgood limestone.

159. A little over three-quarters of a mile down the stream, west of the road, a little dry run exposes the base of the Niagara and the top of the Lower Silurian limestone within five inches of each other. The intermediate part is filled with blue clay and the Lower Silurian *Labechia*.

The Clinton is absent. Immediately above the white basal Niagara limestone occurs the Madison-like clay rock mentioned in the last exposure.

160. From Layton's Mill one mile southeastward, and then half a mile southward, the road is crossed by the Muscatatuck. The salmon-brown Clinton is here at least two feet thick. It is not all exposed. The Madison-like clay rock is two and one-third feet thick; the rubbly limestone is four and one-half feet thick.

161. A little over two miles down the creek, northeast of the junction of a small creek with the Muscatatuck, the salmon-brown Clinton varies from one-third to one foot in thickness. Beneath the Clinton are four feet of white Lower Silurian limestone, with plenty of fossils.

162. A mile and a half southwest of this locality the Muscatatuck crosses the county line. A mile south of the line the Muscatatuck is joined by a stream from the east. A little over a mile up this stream, the salmon-brown Clinton is exposed at a very low fall; it is 20 inches thick. The Clinton contains pebbles of white limestone 6 to 8 inches long, but very flat, containing Lower Silurian fossils, among others, *Strophomena alternata*. Beneath the Clinton lies the white Lower Silurian limestone, which furnished the pebbles.

A short distance down stream, north of the road, the salmon-brown Clinton varies from 18 to 30 inches in thickness. Its uneven base rests on white Lower Silurian limestone containing *Strophomena alternata*.

163. A mile down the stream, along the roadside on the southern bank, the top of the Lower Silurian is 22 feet above the creek. The upper layer is very white, and contains plenty of fossils within two or three inches of the top. Above this is the salmon-brown Clinton, 12 inches thick; then the Madison-like clay rock, four feet; the rubble limestone, four feet; an eight-inch layer of solid Osgood limestone; five feet higher up the base of the Cliff rock or Laurel bed is reached.

164. Three-fourths of a mile westward, directly west of the angle where the road turns south, but on the western side of the stream, in a sort of gully, the Lower Silurian is well exposed. The upper layers are composed of white limestone, containing many fossils, especially *Strophomena alternata*. The Clinton is absent. Directly above the Lower Silurian occurs the base of the Niagara, a light brown limestone, one and one-half inches thick; followed by the Madison-like clayey rock, four feet thick; the rubbly limestone, three feet three inches thick, containing specimens of *Orthoceras*; a clay bed 15 inches thick; eight feet of limestone, the Osgood limestone not being distinguishable from the base of the Cliff or Laurel bed.

JENNINGS COUNTY.

Y. BIG GRAHAM AND OTTER CREEKS.

165. From Benville, in Ripley County, the road goes west, then north, then west again to the Big Graham. The salmon-brown Clinton is here only one inch thick. It contains numerous small pebbles, and is underlaid by four inches of a hard, bluish, Lower Silurian limestone.

166. Half a mile down the creek, on the south bank, there is a good exposure where a dry run enters from the north, the water, in wet weather, falling down the steep banks of the creek at its junction with the latter. The farm house of William Ransdall lies northwest of the locality. Near the creek level, and for four feet above, lies the soft, bluish, argillaceous limestone, lithologically similar to the beds containing *ostracods* near New Marion. The top of the Lower Silurian is clayey and full of loose fossils. The Clinton is absent. The base of the Niagara is 16 feet above the creek. It is a 16-inch layer of white limestone. Above it lie nine feet of clayey shale, the Lower Osgood clay. Above this are three and one-half feet of Osgood limestone, then three and one-half feet of the Upper Osgood clay; above this the Cliff rock or Laurel limestone begins.

A good exposure of the Laurel limestone occurs at the bridge east of San Jacinto, three miles down the creek.

167. From Nebraska, a quarter of a mile southward, a quarter westward, a mile southward, half a mile east, the road leading southward to a large quarry in the Laurel formation is reached. South of the same, along a road leading down into the creek valley (Otter Creek), a good exposure of the rocks of this reigon is reached. From the creek to the top of the Lower Silurian the distance is 57 feet. Lower Silurian fossils occur near the summit of the formation. The top is formed by two to four inches of blue clay and one and one-half inches of hard clay rock. The Clinton is two to three inches think, the exact amount not recorded. It contains pebbles. Above the Clinton are nine and one-third feet of Lower Osgood shaley clay, there being an indurated layer, four inches thick, twelve inches above the base of the clay. The upper part of this clay contains very irregular lenses of rubble limestone with fossils. These limestone lenses become more numerous northeastward, and form the rubble limestone immediately beneath the Osgood limestone. At the present locality the solid Osgood limestone is 24 inches thick, and consists of several layers with thin clay partings, containing loose fossils. Above are 22 inches of Upper Osgood clay, then nine and one-half feet of softer white limestone, the best quarry rock, 23 feet thick, beginning above this level. All of the white limestone above the Upper Osgood clay belongs to the Laurel bed.

168. From the last locality, one and one-half miles west, one mile south, nearly a mile west, and then south to the creek road, a small rock exposure is found southwest of the road junction. The first good exposure, however, is found half a mile further southwest, where a stream crosses the road under a culvert. The fossiliferous Lower Silurian is well exposed east of the road, a short distance down the stream. The Clinton is absent. The clay rock forming the base of the Niagara again contains fossiliferous limestone masses near the top. It corresponds to the Lower Osgood clay, and is ten feet four inches thick. Over it lie 34 inches of solid Osgood limestone; then 16 inches of clay. The Osgood clays and limestone form the face and banks at the side of a small fall. Below the culvert the Cliff rock is exposed.

169. Half a mile westward, then half a mile southeastward, just before reaching a bridge across Otter Creek, in a small run west of the road, the Madison-like clay rock is exposed considerably. Higher up the Laurel bed has been quarried. The level of the Clinton is not exposed. This is a part of the Harvey Weeks farm.

170. A mile westward, northwest of the old Robert Whinnery farm, Otter Creek is crossed by a road. East of this road, on the north side of the creek the Lower Silurian is well exposed. The upper two inches are formed by white limestone, containing *Orthis biforata*, *Protarea vetusta*, etc. Below this white limestone is clay with loose fossils. The Clinton is absent. The basal Niagara consists of white limestone two to three inches thick, with minute crinoidal remains. Above this occur 11 feet of rock corresponding to the Lower Osgood clay; the lower half resembles the Madison clay rock, the upper half is more shaly. The Osgood limestone consists of 12 inches of clayey limestone, 12 inches of crinoidal limestone, eight inches of limestone, four inches of blue clay, 26 inches of limestone layers with thin clay partings. Above this is a partly indurated, irregular breaking clay bed, above which occurs the undoubted Cliff rock or Laurel bed, which is here quarried.

Z. BRUSH, FINCH AND LEATHER CREEKS.

171. About a mile north of Nebraska a small branch of Brush Creek crosses the road. Some distance down the branch the Lower Silurian is exposed, full of fossils; the top of the ordinary limestone beds is five feet above the creek. Above this is a layer of crystalline limestone containing *Tetradium*, and therefore also of Lower Silurian age. The Clinton is absent. The base of the Niagara consists of light brown limestone; six feet higher up, over the clay rock, is limestone with *Pisocrinus gemmiformis*.

172. An excellent exposure is found a quarter of a mile farther north, where another smaller branch of Brush Creek crosses the road,

flowing southward. The Lower Silurian, full of fossils, occurs west of the road. The crystalline limestone, with *Tetradium*, again forms the top of the Lower Silurian. On the west side of the culvert the *Tetradium* layer is seen to be overlaid by blue clay, which is followed by the base of the Niagara. The lower one to one and a half inches of the latter is white and crinoidal limestone. The Clinton is absent.

173. A mile westward, where Brush Creek is crossed by another road, there is an exposure on the north side. Three feet of the bluish argillaceous limestone, containing ostracods at New Marion, is overlaid by one foot of limestone containing *Tetradium;* four and one-quarter feet of Lower Silurian rock containing, near the top, oölitic concretions enclosing fragments of *Orthis*. The oölitic concretions are again seen higher up, 18 feet above the creek. The concretions vary from one-fourth to one-third inch in size. Overlying the upper bed is the crystalline limestone layer, eight inches thick. The Clinton is absent. The base of the Niagara contains *Pisocrinus gemmiformis*. Farther up the road are found five feet of shaly limestone, overlaid by more solid limestone beds of Laurel or Cliff rock age.

174. A mile northwest of locality 172, on the road from Nebraska to Zenas, Finch's branch is reached. A quarter of a mile up stream, on George Lohse's farm, east of Mike Spoeleder, there is an exposure on the east side of the branch, near the base of the low hill land. About six feet above the branch occurs Lower Silurian limestone with oölitic concretions. Above this is a 12-inch layer of limestone with *Tetradium*. This is followed by a 12–15-inch layer, also with concretions. Above this are three feet of thin fragmental limestone with fossils, followed by a clayey layer containing *Labechia*. Above this occur four to ten inches of salmon-brown Clinton limestone, full of white limestone pebbles, the largest being four inches in length. The base of the Niagara is argillaceous, light-brown limestone.

Farther up the stream the Clinton was absent. The *Labechia* layer was overlaid by Niagara limestone containing *Holocystites* and *Pisocrinus gemmiformis*.

175. A mile northward Leather Creek is reached, a short distance south of Zenas. Less than a mile up this creek is a good vertical bank exposure, 20 feet high. It begins with the upper part of the Madison-like, clayey rock, followed by the rubble limestone, then a solid bed of white Osgood limestone, ending with 15 inches of soft clay. This is followed by 12–15 feet of white Cliff or Laurel limestone.

176. Half a mile east of Zenas, the stream, after flowing southward, makes an abrupt bend westward. At the angle a small stream enters Leather Creek from the east. It forms a considerable fall within sight of the road. The ordinary Lower Silurian limestone along the creek is seven feet thick. It is overlaid by the *Labechia* layer. The base of the

Niagara consists of four inches of solid limestone; this is overlaid by four feet of Madison-like greenish and light brown clay rock; four feet of rock, clayey below, turning into a rubble limestone above; 12 inches of Osgood white limestone with crinoidal remains and *Illœnus insignis;* 15 inches of soft clay; 22 feet of Cliff or Laurel limestone.

177. A quarter of a mile east of Zenas, where the road, after going south down the stream, turns westward toward Zenas, the top of the Lower Silurian is exposed 10 feet above the creek level. It consists of solid limestone, the upper part with concretions overlaid by six inches of clay, with *Tetradium, Labechia* and thin limestone fragments, with ordinary Lower Silurian fossils. The Clinton is absent. The white basal Niagara limestone is 12 inches thick. Further up stream about seven feet of light brown limestone with intercalated clays are exposed. This is followed by four inches of limestone with *Pisocrinus gemmiformis*, the same fossil occurring again in a layer of limestone four feet higher up.

AA. SQUAW AND MUSCATATUCK CREEKS.

178. On Squaw Creek, a quarter of a mile north of the county line, the steep east bank shows $12\frac{1}{2}$ feet of Lower Silurian rock, consisting of clayey limestone, full of fossils, weathering into small fragments; over this are four feet of white Lower Silurian limestone with *Strophomena alternata.* The Clinton is absent. The Madison-like clay rock is three and one-fourth feet thick; the rubble limestone is here replaced by thin-bedded even limestones four feet thick. The Osgood limestone is eight inches thick.

179. In a gully half a mile southward, south of the next road crossing the creek from the west, the white limestone at the top of the Lower Silurian contains *Strophomena alternata, Orthis biforata,* branching bryozoans, etc. Above this is the Madison-like clay rock, followed by rubble limestone, the total being seven feet. The Osgood limestone is 12 inches thick. This is overlaid by 12 inches of clay, followed by 10 feet of Cliff or Laurel limestone.

180. A mile southward, in a ravine on the south side of the Muscatatuck, where it takes a westerly course, the top of the Lower Silurian is 15 feet above the creek. The Clinton is absent. The base of the Niagara is a white or light brown siliceous limestone.

181. Half a mile westward and then nearly a mile southward along the Muscatatuck, a small gully is found a short distance north of the east and west road crossing the creek at the mouth of Flat Rock Creek. Lower Silurian bowlders contain oölitic concretions. Along the road itself the top of the Lower Silurian consists of white limestone with *Strophomena alternata.* Within four inches of the same the white Niagara limestone, with *Pisocrinus gemmiformis,* occurs.

182. Nearly a mile and a half southward Wolf Creek enters the Muscatatuck. For about an eighth of a mile northward a road ascends the valley of Wolf Creek and then that of a small branch which enters Wolf Creek where it bends towards the south. The small stream exposes the Lower Silurian. The upper part of the Lower Silurian consists of three feet of blue, clayey limestone, with bryozoans, and at the top with oölitic concretions, followed by two inches of white Lower Silurian limestone. This is overlaid by 11 inches of salmon-brown Clinton, three and one-half feet of clayey limestone, a thin layer of limestone with *Pisocrinus gemmiformis*, six and one-half feet of softer clayey limestone with *Pisocrinus* at various levels, two feet of Osgood limestone, six inches of clay, one foot of limestone, 3 feet of softer limestone, and, finally, the continuous Cliff or Laurel limestone.

183. Directly east of Zenas, on the east side of the Muscatatuck, some distance north of its junction with Leather Creek, the top of the Lower Silurian is 23 feet above the creek. It is full of fossils. The upper 12 inches consist of a white limestone containing *Orthis biforata*, *Orthis occidentalis*, *Streptelasma corniculum*. The Clinton is absent. The base of the Niagara is formed by a solid, Madison-like, clayey rock.

184. Three miles down the creek a road crosses the creek and leads northward to a school house, a quarter of a mile distant. A small stream follows the road. Half way up the road, on the west side, the bed of the stream exposes the Lower Silurian. The crystalline limestone occurs near its top. The Clinton is absent. The clay and rubble stone, corresponding to the Lower Osgood clay and the Osgood limestone, are well exposed in the steep bank. Farther up stream the Cliff or Laurel limestone is exposed.

185. A third of a mile southwestward another small stream enters the creek from the north. No Clinton could be detected.

186. A mile and a half southward the creek bends towards the west. A third of a mile down the creek from this point it is crossed by a road. An exposure occurs along this road. The Lower Silurian is shown at the creek level. It consists of 20 inches of blue limestone with fossils, followed by a bed containing *Labechia* and branching bryozoans. The Clinton is absent. The lower part of the Niagara consists of Madison like clayey banded rock, 76 inches thick, followed by 32 inches of rubble limestone, 16 inches of solid Osgood limestone, 16 inches of soft clay, 12 inches of hard clay rock, overlaid by Cliff or Laurel limestone.

187. On the east bank of the Muscatatuck below its junction with Brush Creek, the rubbly Osgood limestone and the solid limestone bed with *Pisocrinus gemmiformis* are shown. About four and one-half feet higher up the base of the Cliff rock appears. The Lower Silurian is not exposed.

DECATUR COUNTY.

BB. SAND CREEK AND ITS BRANCHES.

About two miles south of Greensburg, on Sand Creek, where the pike turns abruptly westward, the Laurel limestone is quarried.

HARRIS CITY.

Nearly two miles westward, and then a mile southward, at Harris City, the Laurel limestone is again extensively quarried.

Measuring from below upwards, the following layers occur:

14 inches, cap into 2 pieces.
6 inches.
21 inches.
5 inches.
14 inches.
18 inches, cap into 3 pieces.
23 inches.
24 inches, cap into 3 pieces.
27 inches, cap into 2 pieces.
18 inches, cap into 3 pieces.
18 inches, cap into 2 pieces.
18 inches, cap into 2 pieces.
18 inches.
60 inches of various layers used for rubble.

188. About a mile south of Harris City, where a footbridge leads over Sand Creek to Parker's Mill, there is a small exposure on the south side of the creek. The salmon-brown Clinton is about seven inches thick; possibly all of it is not exposed. It contains *Illœnus daytonensis*, *Strophomena tenuis* and *Leptœna (Strophomena) rhomboidalis*. Beneath the Clinton are four inches of bluish limestone, then three feet of clayey, shaly stone, the creek level being three feet lower.

189. About half a mile westward, and then half a mile southward, the creek road passes over a short hill, which exposes along the creek about 28 inches of salmon-brown Niagara. Above the Clinton are two inches of white basal Niagara limestone. Below the Clinton are at least four feet of blue, clayey, crumbling rock, the lower part shaly and containing worm burrows.

Half a mile southward to an iron bridge, a mile eastward, and then a mile southward, Gaynorville is reached. Cobb's Fork is a short distance southward. A quarter of a mile up the creek the southern banks expose a considerable thickness of Lower Silurian limestone, at least 15 feet.

190. A mile east of Gaynorville, a small stream enters Cobb's Fork from the north. Northeast of the junction of these streams a steep bank exposes Lower Silurian limestone with *Strophomena alternata*, about ten feet above the creek bed. The Clinton is absent. The base of the Niagara is a whitish, densely crinoidal rock, four inches thick.

191. A third of a mile up the creek, on the north side of the creek, just before reaching the point where the road crosses over to the north side of the creek, the Lower Silurian is exposed in the form of a bluish, shaly rock without fossils. The Clinton is absent. The base of the Niagara is four inches thick, and is a dense white limestone. The Madison-like, clayey rock is four feet thick. The softer crinoidal limestone overlying it is three and one-half feet thick. It contains *Pisocrinus gemmiformis*. Over this is the horizon of the Osgood limestone.

192. Going from Westport half a mile northeast, a quarter of a mile east, and nearly half a mile southeast, the Boicourt quarry is reached. The Laurel limestone is here extensively quarried. On the south side of the creek, opposite the quarry, the high banks expose Lower Silurian rocks, seven feet of thin limestone and clay full of fossils. The Clinton is absent. The basal Niagara is represented by one and one-fourth feet of white siliceous limestone, merging upward into Madison-like clay rock, four feet thick. Four feet of thin limestones represent the rubble limestones of more eastern sections, and a one-foot layer of solid limestone represents the Osgood limestone. The Cliff limestone is separated by only a thin clay bed.

193. The road from Boicourt's quarry crosses the creek and leads eastward up a steep hill. If, instead of following the road when it turns northward, the easterly course be continued down into Painter Creek, an exposure will be found on the eastern bank of the latter. Seven feet of Lower Silurian limestone terminate above in a layer of white limestone with *Strophomena alternata*. The Clinton is absent. The basal siliceous Niagara limestone is not distinctly demarcated from the Madison-like clay rock above. The thin limestone layers, the Osgood limestone and the Laurel limestone also grade into each other.

194. Half a mile southward, along the next road crossing Painter Creek, the eastern bank exposes about 15 feet of Lower Silurian rock; the upper five feet are clayey and are full of Lower Silurian fossils. Below this are three feet of blue limestone. There is no Clinton. The basal Niagara limestone is a siliceous, brownish rock. Above this are several feet of Madison like clay rock. The Osgood limestone, several feet farther up, contains *Stephanocrinus osgoodensis*. The Laurel bed is found immediately above.

195. A mile down the valley, on the south side of Sand creek, opposite the crossing of a north and south road, the Lower Silurian blue limestone is exposed low down, a little above the creek level, in a little run.

196. Half a mile down the creek the Lower Silurian has disappeared and even the base of the Laurel formation almost reaches the creek level.

197. Directly south of Vernon, opposite a cemetery, is the beginning of a tunnel which leads from one part of the Muscatatuck to a part considerably farther down its course, but owing to the bend in the creek, only a few hundred feet distant from the upper end of the tunnel. A mill at the southern end of the tunnel is known as Tunnel Mill. In the stream below the tunnel, on the south side, the upper part of the Laurel limestone is exposed. The lowest part of the exposure consists of three feet of solid white limestone. Over this are six and a half feet of rubble limestone with chert nodules and intercalated chert layers and 20 inches of solid limestone. Next follow eight inches of indurated clay rock, and 49 inches of Waldron shale, full of fossils. These layers have been penetrated by the tunnel and many beautiful fossils have been collected here, especially by Mr. J. F. Hammel and other geologists at Madison and Hanover, Indiana. Overlying the Waldron shale are 40 inches of hard, clayey limestone; 40 feet of Upper Niagara limestone, most of it dolomitic and of a light brown color; 10 feet of Corniferous limestone, full of corals, nine feet not exposed; three feet of Corniferous limestone, full of brachiopods; a 12 inch layer of limestone, with brachiopods and fish teeth; 12 inches of Waterlime, a dense blue limestone; a 16-inch layer of the Devonian crinoidal layer, with fossils; and 25 feet of black shale. The section above the Waldron shale was taken by ascending the road eastward from the southern mouth of the tunnel and thence northeastward towards Vernon.

The Tunnel Mill south of Vernon lies $7\frac{1}{2}$ miles northwest of Dupont and $12\frac{1}{2}$ miles north of Paris Crossing. It lies 22 miles south of the Waldron shale localities near Hartsville, in Bartholomew County, 33 miles south of St. Paul, 36 miles south of Waldron in Shelby County, and 37 miles south of the Waldron shale locality near Moscow in Rush County. The total distance between the Paris Crossing locality in Jefferson County, and Moscow in Rush County, is 50 miles.

ROCKS ONCE QUARRIED WHICH HAVE PROVEN TO BE USELESS OR OF INFERIOR VALUE.

All extensive quarries in Lower Silurian rocks in southeastern Indiana have proven to be failures. While the thinner limestones are often used for cellar walls, the thicker ledges have turned out to be not durable when exposed to the weather.

The gasteropod layer was extensively quarried by Dean at Marble Hill in 1853. Within five years from that date it was abandoned. The stone is a fairly pure limestone, containing 92 per cent. of the carbonates of lime and magnesia, the latter occurring in only small amounts. The

deposit consists chiefly of detrital fragments of gasteropod shells and of other rounded remains. The cement is more argillaceous and will not withstand the influences of weathering. The result is that when the stone is exposed it soon begins to crumble. Even for interior work it proved unsatisfactory, and the use of the rock has been entirely abandoned.

The Madison rock contains over 50 per cent. of carbonate of lime and about 3 per cent. of carbonate of magnesia. It may therefore be called an impure limestone in spite of the fact that the old analyses give 20 per cent. of silica and 15 per cent. of alumina. It is an argillaceous limestone. The stone was at one time considerably quarried in the immediate vicinity of Madison, and shipped by steamer to various points along the Ohio. It was found, however, to disintegrate quickly. The court house at Louisville, erected from this stone, already looks like a very old building. The quarries have been abandoned for a long time.

Along Cæsar's Creek, between Versailles and Osgood, several thick ledges of blue, fine grained Lower Silurian limestone, within 40 feet of the top of the Lower Silurian, were quarried for a time. They did not withstand weathering, and the quarries have been abandoned.

The Osgood limestone is quarried immediately north of Osgood, and at a few other localities. It is inferior in quality to the Laurel limestone. Owing to the comparatively small thickness of the Osgood limestone section, and to the presence of the much superior Laurel limestone, often in its immediate proximity, the Osgood limestone can not compete with the latter. It is burnt for lime north of Osgood, but the lime does not contain enough carbonate of magnesia to form a good quality of lime. It becomes brittle when used for mortar within a short time, and other kinds of lime are preferred by plasterers. It, therefore, can have only local value.

ROCKS WHICH HAVE AN EXTENDED USE.

THE LAUREL LIMESTONE.

The Laurel limestone is a very fine quality of building rock. It is extensively used for this purpose in Ohio and Indiana, especially at Dayton, Ohio, where the stone is frequently employed to heighten the artistic effect of various public and private buildings. Sometimes entire buildings are constructed of this stone, the pure white color of the rock producing a noble impression, when seen in a massively constructed building.

Chemically, the rock contains about 90 per cent. of the carbonates of lime and magnesia, the better qualities of stone containing only six per cent. or less, of the carbonate of magnesia, although it sometimes forms 10 per cent. of the rock.

The rock occurs in layers which in the immediate neighborhood of any one quarry, preserves a very constant thickness. The different layers in the same quarry vary considerably in thickness. Five, six, seven, eight and nine inches are the more common thicknesses of layers, and layers of this thickness can be secured in almost any quarry. Ledges three and four inches thick are less common in good quarries, but one or more ledges of this thickness occur in almost any quarry, so that most quarries can furnish stone having these dimensions, if desired. In addition to this, nearly all quarries have at least one layer about 16 inches thick. Usually there will be several layers at different levels, varying between 13 and 16 inches in thickness. Ledges 18, 21, 23 inches thick rarely occur oftener than once in any single quarry. Layers thicker than two feet are exceedingly rare, and it is questionable whether these layers will bear a great pressure parallel to the bedding without splitting. The mere fact that a layer of stone can be quarried out into a piece 36 inches thick, as at New Point, does not signify that it is safe to use thickness of this kind for vertical positions where the strain comes parallel to the bedding. Three feet is the greatest thickness cited in the case of any layer of this limestone anywhere in Indiana.

The report on Decatur County, in the Twelfth Annual Report of the Indiana Geological Survey,* is of especial value, for the purpose of securing a good idea of the various thicknesses of the layers of Laurel limestone in that county.

In the body of that report, in connection with the description of the quarries at New Point and Osgood, the thickness of all the layers quarried is recorded. The thickness of the layers at the Harris City quarries is also given. The duplication of many sections of this kind at the different localities would be of no geological value, although of considerable commercial interest. The New Point and Osgood localities are, however, practically the only quarries worked upon any considerable scale, east of the Decatur County quarries along Sand Creek and elsewhere.

During the progress of the investigations included in the present report the writer had constantly in mind the possibility of favorable locations for quarries on a considerable scale, similar to those along Sand Creek in Decatur and northern Jennings County.

The most southern range of localities favorable for the development of new quarries lies along Big Creek, beginning at the Reuben Walker bridge and extending thence up the creek for a distance of three to four miles.

Along the Little Graham, for several miles below New Marion, quarries could be opened, but the layers seem mostly not to exceed six to eight inches in thickness, and many are thinner.

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*1882.

Fine quarry stone is again seen at the bridge over the Big Graham at San Jacinto, and thence eastward at various localities, to New Marion and Tanglewood Church.

The lower Muscatatuck, from the north of Oakdale for several miles up the creek, also exposes quarry stone.

Along Flat Rock Creek exposures of Laurel limestone are abundant, though the layers are often only four inches thick.

The neighborhood of Osgood and New Point is already well exploited for Laurel limestone, though other quarries could be readily started.

At Napoleon a number of localities could be easily quarried, although the exposures do not present a great thickness of this rock.

The districts just mentioned are the most promising for the development of considerable belts of quarries, similar to those along Sand Creek in Decatur County.

The layers of Laurel limestone can usually be readily separated from each other along the horizontal bedding planes between the different layers When a slab has once been freed from the remainder of the rock belonging to the same sheet, it usually can be readily lifted off from the layer below.

In some cases the various layers are cut by very narrow seams. Not uncommonly two sets of seams crossing nearly at right angles are present in the same quarry. Where this is the case, wedges may be introduced along these seams, and advantage may be taken of their presence to secure large slabs of stone without first cutting the rock or loosening it by closely set drill holes.

In those quarries which are not well traversed by seams it is necessary to drive rows of holes into the various layers and then wedging off layers of desired size. For this purpose hand drills are used, but the larger quarries employ steam drills. At New Point, for instance, the required length and width of any slab is secured by placing rows of closely set drill holes along the lines where it is desired to wedge off the stone, and then employing the wedges. The Sullivan channeling machine, manufactured at Claremont, New Hampshire, is sometimes employed in order to produce a clean cut along the shorter diameter of the intended slab, and later a few holes, a foot or more apart, are produced along the length of the slabs, wedges are inserted, and the slabs are then split off.

For the lifting of stone, traveling derricks or derricks on car wheels are very useful. A derrick intended to lift three tons, at a twenty-foot radius from the track on which it rests, is manufactured by the Industrial Works at Bay City, Michigan. The derrick is of iron and cast steel, and moves along a railroad track, enabling the quarrymen to use the derrick at various points in the same quarry. The old-fashioned traveling derricks ran on forty-foot gauges, and, though built of wood, could nevertheless lift much greater weights. The old wooden derrick

at the Al. Arleman quarry, southwest of Osgood, can lift about seven tons.

When it is necessary to drain the quarry the Standard Duplex Pump, manufactured by the Laidlow & Dunn Company, of Cincinnati, Ohio, will be found very serviceable where steam is used.

THE LOUISVILLE LIMESTONE.

The Louisville limestone is quarried both as a building stone and for lime. The piers of the Louisville bridge were constructed of this stone, and the rock is naturally often used near Louisville.

Along the Ohio River, between Charlestown Landing and Utica, it is chiefly used, however, for the production of lime. This lime is then sold under the name of Utica lime. The production of lime is a considerable industry along the river front. Very few quarries are worked for lime at any considerable distance from the river front. The Louisville limestone seems to change its chemical nature northward, the color northward being brownish instead of white, and the grain somewhat finer.

For further remarks on the distribution and general character of the Laurel and Louisville limestones, see the earlier part of the report, under the special description of these formations; also, the various notes under the description of localities, in the main body of the report.